NOV 13 1942

the OIL AND GAS JOURNAL

OVEMBER 12
1942

ANNUAL
A.P.I.
NUMBER

PRICE
O CENTS

Pointed Thoughts

Time Wasted is Lost Forever . . . DON'T BE AN ABSENTEE from your Job

●

STAY ON YOUR JOB and PRODUCE!

●

Make TODAY'S Work your Career for the Duration

●

A Civilian has NO RIGHT TO GO A-W-O-L from a War Job

●

Work at Your War Job NOW for the Freedom to *Choose* a Peace-Time Job Later

●

Only a UNITED *People* With a UNITED *Purpose* Can Preserve Our UNITED STATES

●

Be sure YOU are Doing All You can on *Your* Job before You Blame the Other Fellow for Falling Down on *His*

●

Don't Keep Rumors Alive by Repeating Them

●

DO YOUR JOB as carefully as you think Your Neighbor should do HIS

Space Contributed by the HYDRIL COMPANY

AN ADDED MEASURE OF *Value*

FOR ADDED MEASUREMENT VALUE

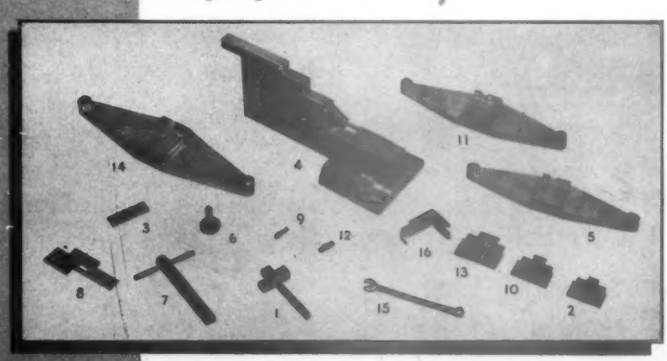
EMCO NO. 0, 1, 2

EMCO NO. 5

EMCO NO. 2½, 3, 4

JIGS AND TOOLS TO SIMPLIFY EMCO REPAIR PROCEDURE

The jigs and tools pictured here have been especially designed to assure an accurately fitted, free running repair job on EMCO Domestic Meters. A similar set is available for repairing Ironclad Meters. The use of these tools and approved repair practice methods is completely described and illustrated in our 80-page Repair and Maintenance Manual. Your meters can be kept in top condition for the duration through the proper installation of modernized EMCO repair parts.



DURING the present emergency you may not be able to secure all the new meters that would normally be required for your expanded operations. Meter repair and maintenance work must, therefore, be done on a scale never before attempted. Here is where the inbuilt extras in EMCO Meters really prove their worth, for these meters have been designed with lasting qualities that provide high performance standards even after serving their normal life span.

EMCO Meters, too, can be renewed and modernized through the installation of interchangeable parts that incorporate, wherever possible, the latest advances in construction.

Good meter repair practice dictates the use of the best in tools and jigs to assure an accurately fitted job. Special factory designed equipment for this purpose is now available. Approved repair procedure for all EMCO and Ironclad Meters is completely described in our 80-page Repair Manual. Meter Shop Foremen, Distribution Superintendents and Measurement Engineers are invited to request it.

PITTSBURGH EQUITABLE METER COMPANY

NEW YORK BROOKLYN DES MOINES MEMPHIS OAKLAND TULSA CHICAGO BOSTON

MERCO NORDSTROM VALVE COMPANY
Main Offices, Pittsburgh, Pa.
NATIONAL METER DIVISION, Brooklyn, N. Y.

KANSAS CITY PHILADELPHIA SAN FRANCISCO LOS ANGELES SEATTLE HOUSTON COLUMBIA BUFFALO

EMCO METERS AND REGULATORS • NORDSTROM LUBRICATED PLUG VALVES

The Oil and Gas Journal

PUBLISHED WEEKLY BY THE
PETROLEUM PUBLISHING COMPANY,
211 S. Cheyenne
TULSA, OKLAHOMA

P. C. LAUINGER, *President* — *Editor*, C. O. WILLSON

S. H. ROURKE, *Business Manager* — LYNN M. NICHOLS, *Managing Editor*

R. C. MAC DOUGALL, *Circulation Manager* — W. T. ZIEGENHAIN, *Refinery Editor*

W. L. NELSON, *Technical Editor* — W. V. HOWARD, Ph.D., *Field Editor*

HARRY F. SIMONS
Production Engineering Editor

Associate Editors

H. STANLEY NORMAN — PAUL REED

ARCH L. FOSTER — NEIL WILLIAMS

District Editors

THOMAS F. SMILEY, Houston, *617 Caroline St.* — CARL HOOT, Tulsa, *211 S. Cheyenne Ave.*

L. P. STOCKMAN, Los Angeles, *Union Oil Bldg.* — HARRY F. SIMONS, Fort Worth, *Petroleum Bldg.*

HENRY D. RALPH, Washington, *Natl. Press Bldg.* — J. P. O'DONNELL, New York, *415 Lexington Ave.*

O. C. PRESSPRICH, Saginaw, *News Bldg.* — TOLBERT R. INGRAM, Denver, *State Office Bldg.*

VICTOR LAURISTON, Chatham, Ont., *35 Stanley Ave.* — A. C. MacINTYRE, Oil City, *Derrick Bldg.*

Advertising

E. KLAPPENBACH, *Vice President*

KENNETH J. LANGLEY, New York, *415 Lexington Ave.* — HOWARD MARKT, Cleveland, *Leader Bldg.*

C. R. FARMER, Chicago, *105 W. Madison* — MITCHELL TUCKER, Tulsa, *211 S. Cheyenne Ave.*

WAYNE RIVES, Houston, *617 Caroline St.* — J. HOWARD TINKHAM, Los Angeles, *1406 S. Grand Ave.*

A. J. CHAMBERS
Twickenham (Middlesex) England—*72 Cole Park Road*

Member
Audit Bureau of Circulations
Associated Business Papers

Table of Contents

Vol. 41, No. 27 — November 12, 1942

News Developments

Trends: All Reports Reflect Strong Position of Low-Gravity Products 53
The A.P.I. Converts to War Service ..... *H. Stanley Norman and Harry F. Simons* 54
Boyd Urges Government Not to Hamper Industry's Efforts 54
How A.P.I. Has Been Adapted to War Program ..... *William R. Boyd, Jr.* 57
PIWC Surveys Outlook for Supplying Enlarged Demand ..... *H. Stanley Norman* 58
These Committees Develop Council's Program 59
Wartime Changes Depreciate Value of Gasoline ..... *J. P. O'Donnell* 60
This Week 61
News From the State Capitals 62
Editorial: Time for a Halt 63
Controlled Materials Plan Is Generally Acceptable to OPC ..... *Henry D. Ralph* 64
Natural Gasoline's Part in War Is Discussed at C.N.G.A. Meet ..... *L. P. Stockman* 69
Oxidation Methods for Chemical Production of Light Hydrocarbons ..... *Hooper Linford* 71
Deaths 74
Natural Gas News 75
Natural Gasoline News 75
Refinery Activity and Expansion 243
Pipe-Line Activity 246
Oklahoma City Production Is Bolstered by Active Drilling ..... *Neil Williams* 250

A.P.I. Section

M-68 Will Result in Drilling 13,000 Fewer Wells in 1942 ..... *Don R. Knowlton* 76
War Causes Dislocations in Natural-Gas Industry ..... *E. Holley Poe* 77
The Army's Internal Security Program ..... *H. G. Reynolds* 79
Deliver 1,400,000 Bbl. Daily to East Coast, OPC Goal ..... *J. R. Parten* 80
A Review of Recent Advances in Drilling Mud Control ..... *Preston E. Chaney* 81
Thermofor Catalytic Process ..... *T. P. Simpson, L. P. Evans, C. V. Hornberg, and J. W. Payne* 96
Method for Analyzing Gasoline Fraction of Petroleum With Preliminary Results on East Texas and Oklahoma Crudes ..... *Frederick D. Rossini, Beveridge J. Mair, Alphonse F. Forziati, Augustus R. Glasgow, Jr., and Charles B. Willingham* 106
Coordination of Conservation Practices in the Various States ..... *E. G. Dahlgren* 118
Critical Analysis of Sweetening Processes and Mercaptan Removal ..... *John Happel, S. P. Cauley, and H. S. Kelly* 136
Present Allocation Practices ..... *D. R. McKeithan* 154
Prediction of the Shrinkage of Crude Oils ..... *D. L. Katz* 179
Constants of Some Hydrocarbons in the Gasoline Boiling Range ..... *Cecil E. Boord* 188
Evaluation of Effective Displacement Pressures for Petroleum-Water Silica Systems ..... *Frank C. Benner, Charles G. Dodd, and F. E. Bartell* 199
Volumeter Practice in the Petroleum Industry ..... *E. E. Ambrosius and E. W. Jacobson* 209
Hydration-Pressure Relations in Clays and Heaving Shales ..... *H. H. Power, Barnaby L. Towle, and Joseph B. Plaza* 215
A Review of Multiple-Zone Well Completions ..... *I. W. Alcorn and W. A. Alexander* 224

Engineering—Operating

Methods of Preparing Butadiene ..... *Gustav Egloff and George Hulla* 228
Chemicals From Petroleum ..... *W. T. Ziegenhain* 233
Questions on Technology ..... *W. L. Nelson* 234
Refinery Ideas 235
Operating Ideas 236
Co$t Engineering: Analysis of Oil Property Deals 237
Engineering Fundamentals: Adjustment of Slide Valves 239
Journalog: Discovery Well, West Liberty Pool, Noble County, Oklahoma 241

Field Developments

Field Developments 249
Permian Basin, Panhandle ..... *W. D. Thorn* 251
Louisiana Gulf Coast ..... *T. F. Smiley* 251
Illinois 252
North Central Texas ..... *W. D. Thorn* 253
Ohio, Indiana, Kentucky 254
Eastern Texas ..... *W. D. Thorn* 255
Southwest Texas 255
Kansas, Nebraska ..... *Carl Hoot* 256
Oklahoma ..... *Carl Hoot* 256
Texas Gulf Coast ..... *T. F. Smiley* 256
California ..... *L. P. Stockman* 257
Michigan ..... *Otto C. Pressprich* 259
North Louisiana-Arkansas 259
Appalachian Fields 260
Canada ..... *Victor Lauriston* 260
Rocky Mountain Area 261
Among Drilling Contractors 268

Markets and Prices

Group 3 Market 272
New York Market 272
A.P.I. Refinery Report 272
Gulf Coast Market 272
Refinery and Tank-Wagon Prices 273
Crude-Oil Prices 273

Additional Features

Personal Paragraphs 270
Equipment News 274
Classified Advertising 276
Advertisers' Index 278

Published weekly by The Petroleum Publishing Co., 211 South Cheyenne, Tulsa, Okla. Subscription price, United States and foreign, 1 year, $6.00; 2 years, $10.00; 3 years, $12.00; 5 years, $15.00. Single copies, 20 cents each. Back copies, when over a year old, 50 cents. Changes of address reaching the Tulsa office of the Journal by Saturday take effect with the following issue. Entered as second-class mail matter at Tulsa, Okla., under the Act of March 3, 1879.

Copyright, 1942, by The Petroleum Publishing Company.

Gasoline
IS THE GOAL OF EMPIRE!

To Day power of the nations of the world is measured in H.P. . . . effectiveness of naval units are dependent on aerial supremacy and freedom will finally be won by mechanized victories. Natural Gasoline has contributed much toward the growth of the automobile, making possible the American Way of Life — it will do more in preserving it. Hanlon-Buchanan is ready with a daily capacity of thousands of barrels of uniform Stabilized Natural Gasoline — STA-VOL-ENE the "Natural" known throughout the World.

Hanlon-Buchanan Inc
PIONEER NATURAL GASOLINE MANUFACTURER

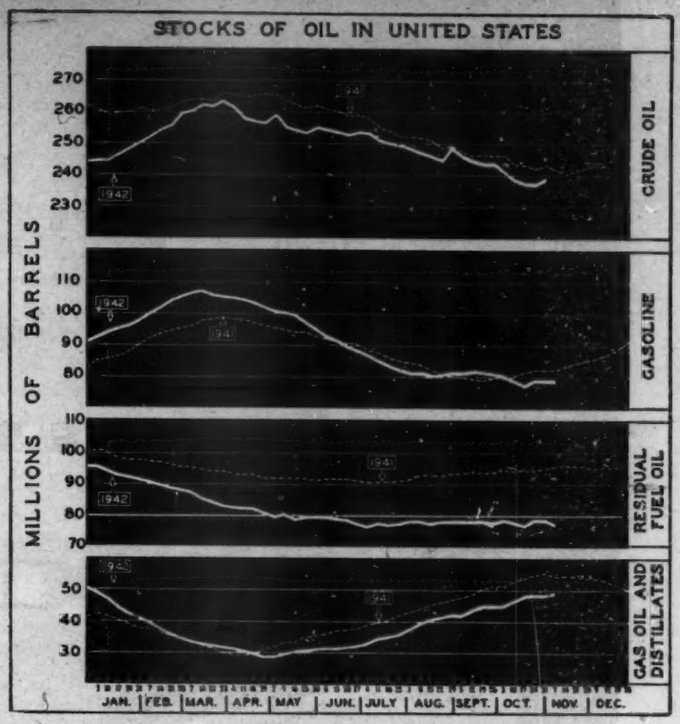
EXPORT TERMINALS:
Goodhope, La. Corpus Christi, Tex.
Houston, Tex. Texas City, Texas

NATIONAL BANK OF TULSA BUILDING
TULSA, OKLAHOMA
P. O. BOX 1539
CABLE ADDRESS: "HANLON" TULSA, U. S. A.

FOREIGN REPRESENTATIVE:
Rees, Williams & Co., Ltd.
4 Lloyd's Ave.
London, England

Trends

All Reports Reflect Strong Position of Low-Gravity Products



THE strong civilian and military demand position of all products classed as kerosene, distillate, and fuel oil under war conditions is revealed in reports of the past few days coming from the A.P.I. annual convention in Chicago, the November meeting of the PIWC, and the latest release of the Bureau of Mines. Considerable information is obtainable from the B. of M. report issued the first of the week covering fuel oil and kerosene sales in 1941. While this report is for a period which ended 10 months ago, the detailed analyses do indicate the demands for these heavier products in the war period that followed.

It shows that under the impetus of the defense program of last year, the railroad demands for distillate and residual fuel oil increased 25.6 per cent over 1940, gas and electric power plants 18.2 per cent, and mines and manufacturing plants 19.5 per cent. The war demands from these outlets this year has been considerably more than the defense requirements of last year and this largely accounts for the fact that the over-all needs for petroleum have not declined in recent months despite the reductions in gasoline consumption. In this connection the B. of M. report estimates that the 1942 demand for distillate fuel oil will total 178 million barrels, a gain of 3 per cent; residual fuel oil, 397 million barrels, a gain of 4 per cent, and kerosene, 72,400,000 bbl., an increase of 5 per cent. It is pointed out that a heavy movement of all of these products is assured for the final quarter of this year.

In regard to heating oils the B. of M. report explains that the demand trend has been upward for several years with 1941 sales totaling 167,514,000 bbl., a gain of 4.4 per cent despite a mild winter season. While no attempt is made to project heating-oil requirements under war conditions it is apparent from the Government's analysis that there is no general substitute for oil heating in homes and buildings now consuming furnace oil at the rate of more than 400,000 bbl. daily based on the yearly average.

It is also significant that the demand classification of "all other uses" in the government report jumped to 46,761,000 bbl. in 1941, a gain of 42.2 per cent, 100 per cent greater than in 1937. This largely reflected the increased needs of the Army and the Navy last year. These requirements have increased greatly over the past year with further large gains assured for 1943. Statisticians of the industry have pointed out that any curtailment in distillate and fuel oil demands through civilian rationing will be more than offset with the increased military requirements.

CRUDE PRODUCTION *3,851,470 bbl. daily average—down 75,040 bbl. One year ago 4,099,405 bbl.*

CRUDE STOCKS *239,266,000 bbl. as of Oct. 31 — up 1,280,000 bbl. One year ago 241,829,000 bbl.*

GASOLINE STOCKS *79,238,000 bbl. as of Nov. 7 — up 79,000 bbl. One year ago 83,223,000 bbl.*

RESIDUAL FUEL-OIL STOCKS **78,317,000 bbl. as of Nov. 7 — down 849,000 bbl. One year ago 96,527,000 bbl.*

GAS OIL AND DISTILLATES *†49,034,000 bbl. as of Nov. 7—up 903,000 bbl. One year ago 53,766,000 bbl.*

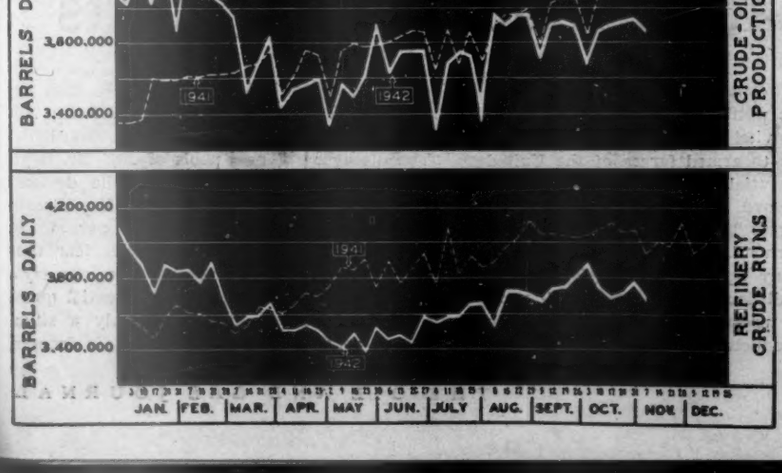
REFINERY RUNS *3,674,000 bbl. daily week ended Nov. 7 — down 97,000 bbl. One year ago 4,080,000 bbl.*

*Last week revised, 79,166,000 bbl.; †48,131,000.

DAILY AVERAGE PRODUCTION FOR WEEK

	Nov. 7 crude oil	Nov. OPC quota all oils	Oct. 31 crude oil
Arkansas	74,200	77,200	73,300
California	706,750	782,000	712,750
Colorado	6,570	7,000	6,520
Eastern fields	97,875	105,200	96,750
Illinois	262,680	280,900	264,600
Indiana	16,125	18,400	17,250
Kansas	268,300	300,700	297,700
Louisiana	322,900	333,800	329,200
North Louisiana	*95,200*	.....	*98,200*
Louisiana Gulf Coast	*227,700*	.....	*231,000*
Michigan	62,600	64,500	60,200
Mississippi	66,000	50,000	69,200
Montana	28,680	24,800	22,560
Nebraska	3,450	3,400	3,400
New Mexico	102,340	100,600	101,550
Oklahoma	367,250	407,500	368,050
Texas	1,372,450	1,381,000	1,410,400
East Texas	*354,800*	.....	*362,000*
West Texas	*211,800*	.....	*231,000*
North Central Texas	*137,600*	.....	*140,000*
East Central Texas	*94,300*	.....	*90,200*
Texas Panhandle	*89,800*	.....	*98,500*
Texas Gulf Coast	*413,900*	.....	*420,000*
Southwest Texas	*70,250*	.....	*68,700*
Wyoming	93,200	94,400	93,080
Total United States	3,851,470	4,031,400	3,926,510

Total production, January 1-November 7, 1942..... 1,182,673,025 bbl.
Same period last year ..... 1,176,621,155 bbl.
Texas shutdown days, November 1, 7; previous week, October 25, 31.



The A.P.I. Converts to War Service

By H. STANLEY NORMAN
and HARRY F. SIMONS

CHICAGO.—Vastly increased obligations on the petroleum industry imposed by the invasion of Africa received searching analysis here this week at the twenty-third annual meeting of the American Petroleum Institute. Expanded war requirements in maintaining adequate supplies at the distant scene of combat, places unforseeable obstacles in the path of delivering adequate petroleum to the East Coast of this country.

Diversion of the few tankers remaining in domestic coastwise service becomes a more immediate threat to the problem of maintaining present deliveries of petroleum to the eastern seaboard and may, oil men here conceded, thrust the entire burden of supplying the East Coast on the railroads, pipe lines and inland waterways. There was general agreement in the A.P.I. sessions throughout the week and in the hotel corridors that many of the adjustments of manufacturing and transportation within the industry, that had been previously considered largely as things to be desired for more perfection in the domestic-supply picture, are now converted to immediate-emergency necessities.

Many of the new aspects of the East Coast supply problem were dealt with more specifically by the Petroleum Industry War Council which held its regular November meeting here Monday and Tuesday. An account of the PIWC deliberations appears on Page 58.

The oil industry's successes in meeting its assignments during nearly a full year of total war, accomplished despite the most radical adjustments in its history, were analyzed before general and group sessions.

There were headaches discussed, too. And several key oil men, both formally and informally, repeated the blunt declaration that continued fulfillment of all essential requirements is dependent on a more sympathetic understanding of the industry's problems at Washington. Operators heard warnings that selective drilling is inevitable, that fewer completions are in prospect for next year because of material shortages and that improved production methods will be forced to absorb some of the shock of curtailed exploration.

This year's A.P.I. convention was strictly a war meeting. Representatives of the various government agencies, including Petroleum Coordinator Ickes, Director of Transportation Joseph B. Eastman, Deputy Petroleum Coordinator Davies and ranking officers of the Army and Navy shared speaking assignments along with operating men and technicians from the industry.

Deep concern was voiced both by government and industry representatives over the failure to discover more reserves. Without making specific commitments, representatives of the Office of Petroleum Coordinator, who availed themselves of the opportunity to report on government policies to the industry through the A.P.I. meeting, conceded that stimulants for exploratory drilling and reserve discovery are necessary. Details of how Washington will cope with the problem are only partially disclosed in enunciations of government men who form the industry's first line of contact with the multitudinous bureaus controlling distribution of the necessary machinery.

Serious inferences against the competitive system were drawn by scores of oil men attending the meeting from recent directives and instructions issued by OPC. Socialization of the oil industry, intimated by Directive 59, applicable now only to the East Coast and its suppliers, and feared imminent elsewhere, was generally branded as wholly undesirable, except as may be absolutely necessary because of war requirements. Abolishment of all federal regulations aimed at collectivism was advocated just as rapidly as conditions permit.

A selective-service system for materials now in hands of the industry, both in inventory and in the ground, was outlined for operators by Don R. Knowlton, OPC director of production. The industry was warned that another reduction in the number of wells drilled is in prospect, probably lowering total completions to approximately 50 per cent of the 1941 rate. Wells in operation will be graded on a basis of salvageable material. Classification 1-A may be considered to include idle wells, those with high water-oil or gas-oil ratios and those closely spaced. Wells in the 1-A group would be the first salvaged and their equipment diverted to better wells.

The industry was invited by Mr. Knowlton to give strong consideration to all methods of improving production from existing reserves. He called attention to a report from Oklahoma that recovery from the state could be increased 500,000,000 bbl. by secondary-production methods and observed that "it takes a lot of wildcat drilling to uncover a reserve of that quantity."

Boyd Urges Government Not To Hamper Industry's Efforts

A PLEA that government agencies refrain from actions that would hamper the oil industry in performing its vital functions of supplying petroleum products to armed forces of the United Nations and essential civilian operations was made by W. R. Boyd, Jr., president of the Institute in his address before the general session Wednesday afternoon. He made no specific charge against any agency. Later references to the increasing difficulty of finding oil were linked with the pressure for a price advance for crude and products by a substantial segment of the industry which left no doubt that remarks were aimed at the Office of Price Administration and the War Production Board.

"The discovery of new pools of oil," Mr. Boyd declared, "has not kept pace with the demand for crude oil. Drilling operations have been drastically curtailed and many informed persons in both industry and government circles fear that the draft on reserves will cripple the industry's ability to provide indefinitely the essential quantities of crude oil required. Certainly a situation does confront the industry that is fraught

with danger and one which should be critically examined by those in authority.

"Production problems," Mr. Boyd went on, "particularly those related to materials and supplies, have received much consideration. The impact of the war on the industry and its financial 'hurts' in one form or another have been discussed at every PIWC meeting, looking toward reimbursement of the industry or units thereof affected, have frequently taken place. The petroleum industry is an army of large and small units. One job is to prevent financial casualties. Dead soldiers cannot fight. Crippled ones can only give limited service.

"The finding of new reserves," Mr. Boyd repeated, "is becoming increasingly difficult and all proper incentives should be offered the wildcatter to explore. It is a historic fact in oildom that price regulates the tempo of the wildcatter's drill. Compensatory prices should be allowed and adequate materials made available to all oil producers."

The industry was challenged by Mr. Boyd to provide the industrial leadership required to meet the present critical conditions and to thus insure the right to survive "this war period and have restored to us thereafter our right to function as a free enterprise in the accustomed American way."

"For our industry," declared Mr. Boyd, "we ask no special privileges. We do hold that men are never so apt to settle a question or problem rightly as when they are permitted to discuss it freely. Fortunately for us, this completely synchronizes with the policy of the petroleum coordinator and his deputy. As for any other agency of the Government having to do with any part of our destiny, we ask that it be not deaf to the 'voice of justice' and that it cooperate with us to prevent any impact of the war from crippling our efficiency or our ability to do the job assigned to us."

Transportation Problem

The overland delivery of 1,400,000 bbl. of petroleum daily to the East Coast by all available facilities, including pipe lines, inland waterways, railroads and motor transport is the ultimate goal of the OPC Transportation Division. An outline of this ambitious transportation program was sketched before the Wednesday morning group session, Division of Production, by J. R. Parten, director of the Transportation Division, Office of Petroleum Coordinator.

Major Parten outlined events leading up to War Production Board authorization for extension of the 24-in. line from Norris City, Ill., to the Philadelphia and New York refining areas on the Atlantic seaboard and said that the "only answer, in our judgment" to the East Coast supply problem is the "building of more pipe lines."

An extended abstract of Major Parten's remarks appears on Page 80 of this issue.

A study of further standardization and simplification of oil-field equipment, particularly tubular goods, was recommended by the central committee on standardization. Work of the committee has already greatly reduced the number of sizes and types of items manufactured under the A.P.I. label and used in the oil fields and the new move is to investigate further possibilities along this line.

In addition, the committee will consider the use of substitute and alternative materials and equipment in its recommendations and code. The resolution to follow this course came after D. R. Knowlton, director of production for OPC, who was attending the committee meeting, was asked for his comments. He suggested a complete study of the substitute material for pipe, including types of steel pipe not commonly used for oil-well casing and not included in the A.P.I. code. He also suggested study of plastics in consideration of materials.

The motion of T. E. Swigart, Shell Pipe Line Co., to study the problem also included alternate operating practices and methods as well as the use of substitute materials.

In the discussion on the subject it was brought out that the industry this year would drill approximately 60 per cent of the number of wells drilled in 1941 but that it had been furnished with less than 10 per cent of the steel it received in the previous year. Next year, Mr. Knowlton pointed out, it is hoped that at least 16,000 wells will be drilled and that OPC was hoping to obtain sufficient material under the controlled materials plan (see story on Page 76). The saving of only a small amount of steel on each well will be an important item in such a program.

The use of spiral-welded casing (made from steel strip) if feasible would save approximately 20 per cent on the amount of steel consumed in completion of shallow and medium-depth wells. The reduction of the factor of safety in casing strings would also be an important item. In this connection, Mr. Knowlton pointed out, some companies were still following a policy of "the heavier the better." One of the committee members commented that the reduction of the safety factor might be a step in the wrong direction. Mr. Knowlton said his suggestion was not to reduce the safety factor dangerously but to eliminate the use of the heavier grades of pipe where they were not needed.

Another item being investigated at the present time is the use of Bessemer steel for casing in oil wells as a substitute for the open-hearth type now employed. There is some unused Bessemer capacity in the nation which might be put into service manufacturing steel for oil-field pipe. Bessemer steel can be made, which will meet the physical specifications required of oil-well casing, it was reported.

Among other committee recommendations was one permitting the use of reasonable size plates in tank manufacture instead of the 72-in. width now required. Bessemer steel for tank tops and bottoms was also recommended. Use of the A.P.I. code by manufacturers, jobbers and users was also urged as the standardization system reduced the number of items manufactured and also insures interchangeability. The interchangeability of parts, the result of years of work by the standardization committee, is bearing fruit at the present time when considerable difficulty is being experienced obtaining many items.

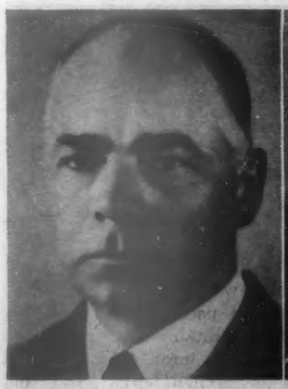
Need Natural-Gas Pipe Lines

A major program of natural-gas pipe-line construction within the next 18 months will be necessary in the states comprising OPC District 2 if the current rate of supply is to be maintained. This conclusion was drawn by E. Holley Poe, director of the OPC Natural Gas and Natural Gasoline Division, in reviewing the nation-wide outlook for this phase of the industry. He considers the prospects dull for discovery of any new major reserve for duration of the war. Further modification of M-68 restrictions may become necessary in certain areas in order to meet demand for natural gas at war plants and to prevent domestic hardships, he told those attending a group session of the A.P.I. Division of Production. Further remarks by Mr. Poe are presented on Page 77.

The safety of the physical facilities of the

The A.P.I. Coverage . . .

Highlights of the twenty-third annual meeting of the American Petroleum Institute are summarized on these first few pages. Nearly 60 additional pages of this issue, starting on Page 76, are devoted to complete papers, excerpts, and digests of others all presented at this week's technical and general sessions of the A.P.I. at Chicago.

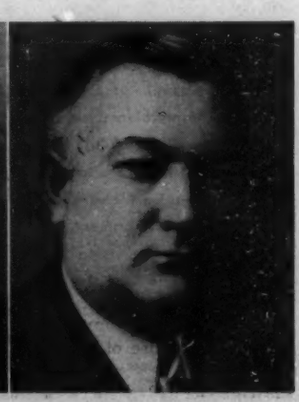


J. HOWARD PEW
Vice president for refining

GEORGE A. HILL, JR.
Vice president for production

ERIC V. WEBER
Vice president for marketing

OTTO D. DONNELL
Treasurer of the Institute



LACEY WALKER
Secretary and assistant treasurer

The A. P. I. Converts to War Service

petroleum industry is a prime concern of management even in peacetime, said Bruce K. Brown, assistant deputy petroleum coordinator. War imposes an infinitely greater hazard from enemy sabotage and direct attack. The industry is charged with the duty of assuring a continued supply of oil for war and that responsibility cannot be assigned or escaped.

Military Effort Not Enough

The security of plants against sabotage by delay, contamination of product, or by actual destruction cannot possibly be obtained solely through military effort. The military, or the civil agencies such as Office of Civilian Defense, can at best set standards of protection. Actual security can only come through management when it makes available the whole force of its control over its supervisory staff and its working personnel. Failure of management to take the proper steps is due to the belief there is no organized sabotage in this country and that "it can't happen to them."

The ones doing this sabotage can best be caught by counterespionage. In war we have the duty to use every means in our power to prevent every act that will in any way retard our victory.

Industry Has Job of Protecting Its Own Facilities

THE job of protecting oil-industry facilities is up to the industry itself, Philip Bastedo, deputy director of the Office of Civilian Defense, pointed out. Although there will be Army inspectors and inspectors from the Bureau of Mines and Federal Power Commission, it will still be up to the industry, Mr. Bastedo said.

"At the present time the Office of Petroleum Coordinator, with Mr. Mason as director of the Facility Security Division, is working very hard to establish an organization of highly trained inspectors. Already Mr. Mason has picked an admirably qualified staff of regional representatives and the work of drafting competent technicians from the oil companies to act as inspectors is well under way. It is hoped that as this staff is developed it will be able to take over more and more of the responsibility for maintaining adequate standards of protection in the oil industry.

"You are perhaps beginning to wonder where the oil companies and other owners and operators fit into the picture. That brings us to what I regard as the most important part of Executive Order 9165, namely, the provisions stating that the primary responsibility of guarding and protecting essential facilities from sabotage rests upon the owner or operator. This cannot be emphasized too strongly. No federal agency or combination of them could even begin to do the job. At most the Government can recommend, supervise and tighten up here and there, but the real responsibility rests upon business men who are willing to spend the money and make the sacrifices that adequate protection demands. You in the oil industry have shown that you are keenly aware of the role that you must play. The formation of the committee on protection of petroleum facilities and the vast amount of work which has been carried on by your subcommittee working in every region is an inspiring example of an industry anxious to face the problems created by war. You will agree, I know, that every effort must be made not only to preserve the structure that has been set up but to improve it and to intensify the efforts that are being made. I believe that all the different elements in this picture are as eager to bring about a maximum protection as possible. If the good will and cooperation that I have seen continues that result is going to be achieved."

●

Technical Papers

Vast strides have been made in recent years toward real conservation, according to D. R. McKeithan, of Phillips Petroleum Co., Bartlesville, Okla., and E. G. Dahlgren, of the Interstate Oil Compact Commission. By far the greatest proportion of all the petroleum reserves in the country now are produced under these principles.

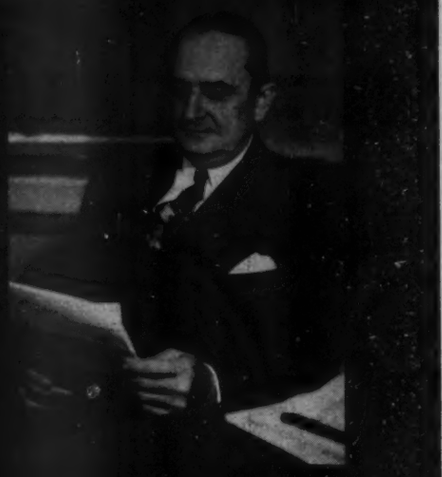
Despite differences in the methods of allocating production, many of them widely divergent, the program in most of the states is quite satisfactory, Mr. McKeithan declared. It is apparent, he said, that one basic law or rigid formula could not be applied reasonably to meet all the varied conditions and local problems within the separate states. Many of the differences have arisen because of the differing evolution of conservation in the states.

Both speakers traced briefly the history of conservation controls throughout the country, and

Chairmen of group sessions at the A.P.I. meeting included: (above) W. S. Farish, president of Standard Oil Co. (New Jersey), presided over meeting devoted to protection of petroleum facilities; John R. Suman, vice president of Humble Oil & Refining Co., presided at production division conference, featuring drilling and production problems and T. G. Delbridge, manager of research and development, Atlantic Refining Co., conducted a refining division session at which manufacturing in wartime was the central topic. Right: J. Bennett Hill, manager of research and development, Sun Oil Co., presided at a session on refining problems and processes; Leo Huff, Pure Oil Co., conducted a meeting on automotive transportation and Paul D. Torrey, consulting engineer, directed a session of the production division concerning drilling and production practices

How A. P. I. Has Been Adapted to War Program

By WILLIAM R. BOYD, JR.
President American Petroleum Institute



IN every possible way the American Petroleum Institute has been streamlining its activities to convert them to war service. But it is a remarkable fact that, when we first were called upon to meet the war's demands, we found that a large proportion of our activities already were geared to the job that had to be done.

Obviously, the Petroleum Industry War Council and the Government had to assume the main burden of the oil industry's part in the war, but the A.P.I. work listed below has contributed much to the service of the war.

Standardization.—The Institute's program of standardization, carried on progressively since 1924, fitted perfectly the needs of the War Production Board for material conservation, and of the armed forces for construction specifications.

Accident prevention.—The supreme importance of manpower conservation permeates all government thinking today, and the Institute's long-time accident-prevention program has provided a solid foundation for intensive concentration on industrial safety in the vital oil industry.

Fire prevention.—Skilled fire prevention and fire fighting techniques developed by the oil industry through cooperative effort in the Institute framework have been enlisted bodily in the war effort.

Protection of petroleum facilities.—Well-organized committees of the Institute charged with developing a program of protection and cooperating with the many government agencies involved, even before the war, were taken over intact to continue their work under the Petroleum Industry War Council.

Refinery standards.—The code for unfired pressure vessels, the refinery inspection program, and other work of the Institute's refining division have been of great help in the war-accelerated expansion of certain manufacturing facilities.

Statistics.—The Institute's weekly operating statistics and other special services were ready and waiting to be used as highly important tools by the Government and the industry to watch all-important trends in supply and demand.

Water transportation.—Expert assistance in answering technical questions and giving operational advice was requested by the Government, and the Institute's tanker and barge groups supplied an expert to serve as a full-time governmental consultant.

Automotive transportation.—Growing importance of tank trucks to substitute for tank cars and other petroleum carriers on increasingly longer runs has dovetailed with the continuing work of the Institute's automotive transportation committees.

Other activities.—The impact of the war has touched nearly every other Institute activity. Those that do not contribute directly to that single purpose have been dropped for the duration, and the Institute now exists solely in the war service of the industry.

described in some detail the actual methods of allocation of oil production in each of the important oil-producing states.

Mr. Dahlgren reported that the Interstate Oil Compact Commission, the voluntary association that now numbers 12 leading oil states as members, derives most of its strength from this voluntary relationship and from the fact that it has no power of compulsion. Public opinion alone enforces the commission's suggestions and recommendations, he said, and the commission has reduced appreciably antagonism and rivalries among the states.

Two other papers at this session described recent progress in the use of induced pressures—secondary recovery—to increase the production of oil from certain fields. Recently the injection of salt water into the world's greatest oil field, the East Texas field, was authorized, and the method being used was reported by J. Zeppa, of Delta Drilling Co., Tyler, Tex. The salt water used is produced along with the oil and returned under pressure to the underground oil formation.

Paul D. Torrey, of Houston, Tex., authority on secondary-recovery methods, described the role that these methods play in helping oil producers meet the demands of the war effort.

Petroleum refineries rapidly are becoming more flexible, enabling them to produce vaster quantities of high-octane aviation fuels and other war products now, and the petroleum products desired when peace comes, according to a report at a refining session.

By the end of 1943 total capacity of the most modern catalytic cracking plants will be 1,000,000 bbl. a day, or nearly one-fourth of the country's total refinery capacity, it was said. Catalytic cracking first was introduced less than 10 years ago. Two processes, the Houdry and the Fluid, already are widely used, and a third process, the Thermofor, was described in detail.

The new process is said to be highly flexible, and to be equally adaptable to the production of such war products as superaviation fuels, butanes and butylenes for further processing into aviation fuels and butadiene for synthetic rubber, aromatics for explosives and other products, and high-quality fuel oils, and to the peacetime production of whatever petroleum products are then most in demand. Coauthors of the paper were T. P. Simpson, L. P. Evans, C. V. Hornberg, and J. W. Payne, all of the Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

The A. P. I. Converts to War Service

Authors of a paper discussing these problems reported to the session that the traditional "doctor" test has lost its significance, and there is a distinct trend to allow higher sulfur content, with no loss in quality or performance of the gasoline. It has become doubly important now for refiners to review their treating program, they say, because the necessary chemicals are needed for war work. John Happel, S. P. Cauley, and H. S. Kelly, all of the Socony-Vacuum Oil Co., Inc., Brooklyn, N. Y., were coauthors of the paper.

Methods of protecting petroleum storage tanks against corrosion, one of the most serious problems that regularly confront the industry, were reviewed in a paper by F. L. Newcomb, of Standard Oil Development Co., Elizabeth, N. J.; E. S. Dixon, Texas Co., Port Arthur, Tex.; and C. F. Kelly, Humble Oil & Refining Co., Baytown, Tex. Recommended, particularly in the face of shortage of critical metals, is a gunite or gun-sprayed cement lining for metal tanks now in use.

Using only one well to get oil or gas from two or more levels in certain fields has become a vital material-conservation measure, and has saved an average of 105 tons of steel, or 46 per

(Controlled on Page 266)

PIWC Surveys Outlook for Supplying Enlarged Demand

By H. STANLEY NORMAN

CHICAGO.—A deficit of 100,000 bbl. daily, possibly more, during the next 5 months in the petroleum supply on the East Coast required to meet the rationed demand was predicted here Monday by the Petroleum Industry War Council's committee on economics.

The outlook for supplying irreducible war-plant demand and rationed civilian requirements changed abruptly over the week end with the opening of the African front which, curbstone strategists among the oil men believe, will build the springboard for an attack on the European Continent. Economists, hastily revising their calculations, envisage almost complete withdrawal of tankers from the East Coast service in order to make certain beyond question that American forces in Africa will have adequate fuel.

Some members of the PIWC were alarmed at the critical turn of the dual task of supplying the extensive African campaign and, at the same time and with virtually the same marine facilities, augmenting shipments to the East Coast. Transportation of petroleum products to the East Coast is failing to meet even the rationed demand and it now appears that there will be a deficit of around 100,000 bbl. a day for the next 5 months, the economics committee reported November 9.

Authorization to extend the "big inch" line to the Atlantic seaboard will relieve the situation by next summer, the committee pointed out, but inability of tank-car movements to meet the more optimistic estimates and the fact that rationing has not lowered gasoline consumption as far as had been anticipated contribute to the outlook for a shortage during the next few months.

William R. Boyd, Jr., PIWC chairman, said that the committee's report indicated that the deficiency could only be met by additional rationing or by increased tanker deliveries. Possibilities of increasing marine movement from the Gulf Coast to eastern consumers, he pointed out, must be determined by military considerations. The committee assumed that fuel-oil rationing already was at the lowest point to which it could go, except to force additional conversion to coal where possible. A suggestion was made, according to off-the-record reports, that the minimum gasoline-ration unit in the eastern states should be reduced to 3 gal. per week for nonessential consumers, a decline of 1 gal. from the existing quota. Oil-industry leaders are also proposing a general tightening up of eastern rationing enforcement, including a more critical examination of applications for higher quotas.

The council adopted a strong resolution condemning proposals that the Government subsidize the industry for exploratory drilling. Opposition was based on the belief that such a method would be fallacious, inadequate, capricious, impossible to administer, fairly and practically, costly to the Government and the public and not consistent with American tradition.

Instead of the subsidy plan, the council urged the establishment of a fair and adequate price for crude oil and the continuation of the depletion allowance and the right to charge to expense the intangible costs of drilling. This method of encouraging exploration, the council resolved, inspires more scientific development and more efficient production methods. The resolution requested the petroleum coordinator to make known the feelings of the industry to other government agencies and to do all within his power to prevent inauguration of federal subsidies.

Prompt and adequate allocation of tires to oper-

(Continued on Page 61)

PIWC Roster Shows Cross-Sectional Nature of Industry's Mouthpiece

W. R. BOYD (chairman), president, American Petroleum Institute, New York.

COL T. H. BARTON, president, Lion Oil Refining Co., El Dorado, Ark.

BURT R. BAY, president, Northern Natural Gas Co., Omaha, Neb.

C. S. BEESEMYER, vice president, Gilmore Oil Co., Los Angeles, Calif.

SIDNEY BELITHER, executive vice president, Shell Oil Co., Inc., San Francisco, Calif.

M. L. BENEDUM, president, Benedum-Trees Oil Co., Pittsburgh, Pa.

PAUL G. BLAZER, president, Ashland Oil & Refining Co., Ashland, Ky.

J. S. BRIDWELL, president, Bridwell Oil & Gas Co., Wichita Falls, Tex.

JOHN A. BROWN, president, Socony-Vacuum Oil Co., Inc., New York.

FRANK BUTTRAM, president, Independent Petroleum Association of America, Oklahoma City, Okla.

J. W. CARNES, vice president, Sinclair Refining Co., New York.

H. EARL CLACK, president, Clack Oil Co., Havre, Mont.

ROBERT H. COLLEY, president, Atlantic Refining Co., Philadelphia, Pa.

H. D. COLLIER, president, Standard Oil Co. of California, San Francisco, Calif.

HOWARD A. COWDEN, president, Consumers Cooperative Association, North Kansas City, Mo.

HENRY M. DAWES, president, Pure Oil Co., Chicago, Ill.

SYLVESTER DAYSON, president, Premier Oil Refining Co., Longview, Tex.

R. E. DECKER, president, National Oil Marketers Association, Detroit, Mich.

B. E. DEVERE, president, Independent Refiners Association of California, Los Angeles, Calif.

O. D. DONNELL, president, Ohio Oil Co., Findlay, Ohio.

J. FRANK DRAKE, president, Gulf Oil Corp., Pittsburgh, Pa.

WILLIAM S. FARISH, president, Standard Oil Co. (New Jersey), New York.

W. H. FERGUSON, executive vice president, Continental Oil Co., Denver, Colo.

JACOB FRANCE, president, Mid-Continent Petroleum Corp., Baltimore, Md.

B. I. GRAVES, vice president, Tide Water Associated Oil Co., New York.

WALTER S. HALLAHAN, president, Plymouth Oil Co., Pittsburgh, Pa.

D. P. HAMILTON, president, Root Petroleum Co., Shreveport, La.

JAKE L. HAMON, president, Cox & Hamon, Dallas, Tex.

ROBERT W. HENDEE, general manager, Colorado-Interstate Gas Co., Colorado Springs, Colo.

C. L. HENDERSON, president, Western Petroleum Refiners Association, care of Vickers Petroleum Co., Wichita, Kans.

GEORGE A. HILL, JR., president, Houston Oil Co. of Texas, Houston, Tex.

DANA HOGAN, president, Hogan Petroleum Co., Los Angeles, Calif.

W. T. HOLLIDAY, president, Standard Oil Co. (Ohio), Cleveland, Ohio.

D. W. HOVEY, president, Gulf Coast Refiners Association, Houston, Tex.

WILLIAM F. HUMPHREY, president, Tide Water Associated Oil Co., San Francisco, Calif.

J. C. HUNTER, president, Mid-Continent Oil and Gas Association, Washington, D. C.

A. JACOBSEN, president, Amerada Petroleum Corp., New York.

ROY B. JONES, president, Panhandle Producing & Refining Co., Wichita Falls, Tex.

CHARLES S. JONES, president, Richfield Oil Corp., Los Angeles, Calif.

W. ALTON JONES, president, Cities Service Co., New York.

RALPH B. LLOYD, president, California Oil and Gas Association, Los Angeles, Calif.

H. A. LOGAN, president, National Petroleum Association, United Refining Co., Warren, Pa.

J. M. LOVEJOY, president, Seaboard Oil Co. of Delaware, New York.

CHARLES P. McGAHA, president, National Stripper Well Association, Wichita Falls, Tex.

N. C. McGOWEN, president, United Gas Pipe Line Co., Shreveport, La.

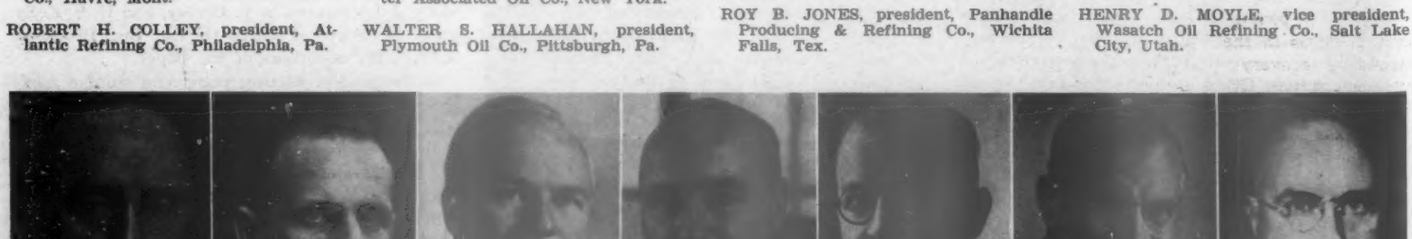
B. L. MAJEWSKI, vice president, Deep Rock Oil Corp., Chicago, Ill.

A. C. MATTEI, president, Honolulu Oil Corp., San Francisco, Calif.

PARKER L. MELVIN, president, Pennsylvania Grade Crude Oil Association, Bradford, Pa.

WILLIAM MOELLER, vice president, Southern California Gas Co., Los Angeles, Calif.

HENRY D. MOYLE, vice president, Wasatch Oil Refining Co., Salt Lake City, Utah.



R. H. COLLEY *W. S. S. RODGERS* *W. ALTON JONES* *DR. R. E. WILSON* *B. L. MAJEWSKI* *JOHN D. GILL* *J. F. ROBINSON*

These seven men are among those heading standing and special committees through which much of the council's work is accomplished

S. B. MOSHER, president, Signal Oil & Gas Co., Los Angeles, Calif.

BURTON W. MUSSER, general counsel, Utah Oil Refining Co., Salt Lake City, Utah.

JOHN W. NEWTON, vice president, Magnolia Petroleum Co., Beaumont, Tex.

I. A. O'SHAUGHNESSY, president, Globe Oil & Refining Co., St. Paul, Minn.

J. HOWARD PEW, president, Sun Oil Co., Philadelphia, Pa.

E. E. PYLES, Los Angeles, Calif.

FRANK PHILLIPS, chairman, Phillips Petroleum Co., Bartlesville, Okla.

E. B. REESER, president, Barnsdall Oil Co., Tulsa.

J. FRENCH ROBINSON, president, East Ohio Gas Co., Cleveland, Ohio.

W. S. S. RODGERS, president, Texas Co., New York.

CHARLES F. ROESER, president, Roeser & Pendleton, Fort Worth, Tex.

E. G. SEUBERT, president, Standard Oil Co. (Indiana), Chicago, Ill.

R. S. SHANNON, president, Minnelusa Oil Corp., Denver, Colo.

HARRY F. SINCLAIR, president, Consolidated Oil Corp., New York.

W. G. SKELLY, president, Skelly Oil Co., Tulsa.

W. L. STEWART, JR., executive vice president, Union Oil Co. of California, Los Angeles, Calif.

REESE H. TAYLOR, president, Union Oil Co. of California, Los Angeles, Calif.

LAWRENCE VANDER LECK, president, Oil Producers' Agency of California, Los Angeles, Calif.

R. van der WOUDE, president, Shell Union Oil Corp., New York.

E. V. WEBER, president, Ohio Petroleum Marketers Association, care of Eureka Oil Co., Cincinnati, Ohio.

H. C. WIESS, president, Humble Oil & Refining Co., Houston, Tex.

ROBERT E. WILSON, president, Pan American Petroleum & Transport Co., New York.

These Committees Develop Council's Programs

Council Staff

1625 K. Street, Northwest, Washington, D. C.
Telephone—District 2820

WILLIAM R. BOYD, JR., chairman, Russell B. Brown, Fayette B. Dow, J. L. Dwyer and Joseph E. Pogue, assistants to the chairman; Allan H. Hand, secretary-treasurer.

Standing Committee on Production

O. D. DONNELL, chairman; Walter S. Hallahan, George A. Hill, Jr., R. S. Shannon, E. E. Pyles and H. H. West, secretary.

Standing Committee on Natural Gas and Gasoline

J. FRENCH ROBINSON, chairman; Burt R. Bay, Robert W. Hendee, N. C. McGowen and William Moeller.

Standing Committee on Refining

R. H. COLLEY, chairman; Paul G. Blazer, Henry D. Moyle, John W. Newton and W. L. Stewart, Jr.

Standing Committee on Transportation

W. ALTON JONES, chairman; Charles S. Jones, Burton W. Musser, E. G. Seubert, H. C. Wiess and J. E. Dyer, secretary.

Standing Committee on Marketing

B. L. MAJEWSKI, chairman; C. S. Beesemyer, J. W. Carnes, vice president, Sinclair Refining Co.; H. Earl Clack and Roy B. Jones.

Subcommittee on product conservation.

B. I. GRAVES, chairman; W. H. Kershaw, Texas Co.; J. A. Miller, Standard Oil Co. of New Jersey, and J. E. Dyer, secretary.

Subcommittee on automotive transportation.

F. B. HUFNAGEL, JR., chairman, Sun Oil Co., Philadelphia, Pa.; E. M. Fitz, Shell Oil Co., Inc., San Francisco, Calif.; Leo Huff, Pure Oil Co., Chicago, Ill.; Gavin Laurie, Atlantic Refining Co., Philadelphia, Pa.; Oscar Lynch, Humble Oil & Refining Co., Houston, Tex., and J. A. Brusso, Continental Oil Co., Denver, Colo.

Subcommittee on equipment.

C. C. BENEDICT, chairman, Socony-Vacuum Oil Co., Inc., New York; B. E. Devere, John Lang, Lang Co., Salt Lake City, Utah; Dan O'Connell, Texas Co., Houston, Tex., and William K. Tell, Standard Oil Co. (Indiana), Chicago, Ill.

Subcommittee on lubrication and containers.

L. P. LOCHRIDGE, chairman, Sinclair Refining Co., New York; K. C. Baker, J. D. Streett & Co., St. Louis, Mo.; D. P. Clark, Gulf Oil Corp., Pittsburgh, Pa.; C. M. Davison, Standard Oil Co. (New Jersey), New York; J. M. Evans, Tide Water Associated Oil Co., San Francisco, Calif.; E. W. Hutton, Refiners Marketing Co., Los Angeles, Calif.; D. G. Hubbard, Continental Oil Co., Denver, Colo.; H. J. Kennedy, Continental Oil Co., Ponce City, Okla.; F. C. Kerns, Texas Co., New York; J. M. Koch, Quaker State Refining Co., Oil City, Pa.; H. D. Miller, Shell Oil Co., Inc., New Orleans, La.; C. B. Prescott, Gulf Oil Corp., New Orleans, La.; H. G. Vesper, Standard Oil Co. of California, San Francisco, Calif.; L. C. Welch, Standard Oil Co. (Indiana), Chicago, Ill., and K. W. Yeates, Wasatch Oil Refining Co., Salt Lake City, Utah.

Standing Committee on Petroleum Economics

DR. ROBERT E. WILSON, chairman; W. S. Farish, W. H. Ferguson, John D. Gill, Atlantic Refining Co., Philadelphia, Pa.; A. Jacobsen, A. C. Mattei, J. Howard Pew, Charles F. Roeser and Fred Van Covern, secretary.

Economic advisers: Prof. R. S. Meriam, Soldiers Field, Cambridge, Mass.; Dr. Joseph E. Pogue, Chase National Bank, and D. Alexander Sachs, Lehman Brothers, New York.

Subcommittee on petroleum economics.

STEWART P. COLEMAN, chairman, Standard Oil Co. (New Jersey), New York; Harold B. Fell, Independent Petroleum Association of America, Tulsa; R. G. Gonzales, Humble Oil & Refining Co., Houston, Tex.; David G. Gray, chairman, statistical subcommittee, District 3, Houston, Tex.; E. T. Knight, Atlantic Refining Co., Philadelphia, Pa.; J. A. Lentz, regional manager, Continental Oil Co., Denver, Colo.; Clarel B. Mapes, Mid-Continent Oil and Gas Association, Tulsa; A. J. McIntosh, Socony-Vacuum Oil Co., Inc., New York; J. M. Sands, Phillips Petroleum Co., Bartlesville, Okla.; H. N. F. Schwall, Shell Oil Co., Inc., New York; Sidney V. Swensrud, Standard Oil Co. (Ohio), Cleveland, Ohio; Earl Wagy, Standard Oil Co. of California, San Francisco, Calif., and Fred Van Covern, secretary.

Standing Committee on Protection of Petroleum Facilities

W. S. FARISH, chairman; Frank Buttram, H. D. Collier, Henry M. Dawes, J. F. Drake, W. H. Ferguson, C. L. Henderson, George A. Hill, Jr., Dana Hogan, J. C. Hunter, H. A. Logan, N. C. McGowen, B. L. Majewski, J. Howard Pew, W. S. S. Rodgers, E. G. Seubert, W. G. Skelly and David V. Stroop, secretary.

Regional subcommittees.

Northeastern region: E. H. BARLOW, chairman, Standard Oil Development Co., and R. W. Black, vice chairman, Standard Oil Co. (New Jersey), both of Elizabeth, N. J.

Southeastern region: WILEY MOORE, chairman, Wofford Oil Co., and H. A. Grumann, vice chairman, Sinclair Refining Co., both of Atlanta, Ga.

Great Lakes region: L. S. WESCOAT, chairman, Pure Oil Co., Chicago, Ill., and P. L. Krauel, vice chairman, Standard Oil Co. (Indiana), Whiting, Ind.

Central region: JOHN C. DAY, chairman, Western Petroleum Refiners Association, Tulsa.

Western region: J. L. HANNA, chairman, Standard Oil Co. of California; Dana Hogan, vice chairman, and A. C. Rubel, vice chairman, Union Oil Co. of California.

Gulf Coast region: FRANK L. WALLACE, chairman, and Phillip Campbell, vice chairman, both with Texas Co., at Port Arthur, Tex.

Temporary Pipe-Line Management Committee

W. ALTON JONES, chairman; R. H. Colley, J. F. Drake, R. W. Gallagher, vice president, Standard Oil Co. (New Jersey); W. F. Humphrey, W. S. S. Rodgers, E. G. Seubert, H. C. Wiess and J. E. Dyer, secretary.

Temporary pipe-line engineering subcommittee.

W. R. FINNEY, chairman, Standard Oil Co. (New Jersey); Charles Bunje, Jr., president, Illinois Pipe Line Co., Findlay, Ohio; G. J. Hanks, vice president, Tide Water Associated Oil Co., New York; B. E. Hull, president, Texas Pipe Line Co., Houston, Tex.; C. H. Kountz, vice president, Sinclair Refining Co., Independence, Kans., and T. E. Swigart, president, Shell Pipe Line Corp., Houston, Tex.

Temporary Committee on Synthetic Rubber

W. S. S. RODGERS, chairman; John A. Brown, William H. Ferguson, Jacob France, William F. Humphrey, Frank Phillips, Charles F. Roeser, H. F. Sinclair, R. van der Woude,, E. V. Weber, Dr. Robert E. Wilson, P. C. Keith, technical adviser and consultant, M. W. Kellogg Co., New York, and J. H. Pipkin, secretary, Texas Co.

Advisory subcommittee on rubber economics.

JOSEPH E. POGUE, chairman; W. C. Allen, Texas Co., New York; C. L. Burrill, Standard Oil Co. (New Jersey), New York; W. L. Finger, Standard Brands Co., New York; R. S. Mitchell, Shell Oil Co., Inc., New York; L. W. Moore, Pan American Petroleum & Transport Co., New York, and George H. Taber, Jr., Sinclair Refining Co., New York.

Advisory Committee on War Products

T. G. DELBRIDGE, chairman, manager of research and development, Atlantic Refining Co., Philadelphia, Pa.; E. W. Isom, vice president, Consolidated Oil Corp., New York; K. G. McKenzie, assistant to vice president, Texas Co., New York; G. G. Oberfell, vice president, Phillips Petroleum Co., Bartlesville, Okla.; Daniel Pyzel, vice president, Shell Oil Co., New York; J. B. Rather, manager of research and development, Socony-Vacuum Oil Co., Inc., New York, and R. P. Russell, executive vice president, Standard Oil Development Co., New York.

Standing Committee on Cost and Price Adjustments

JOHN D. GILL, chairman; John A. Brown, W. H. Ferguson, W. F. Humphrey, Frank Phillips and Charles F. Roeser.

Temporary Committee on Impact of the War on the Petroleum Industry

JOHN D. GILL, chairman; John A. Brown, Frank Buttram, W. H. Ferguson, B. I. Graves, D. W. Hovey, W. F. Humphrey, A. Jacobsen, W. Alton Jones, B. L. Majewski, Frank Phillips and Charles F. Roeser.

Wartime Changes Depreciate Value of Gasoline

By J. P. O'DONNELL

NEW YORK.—Revisions in yields, shifts in the balance of refining among the various districts and changes in prices have combined to make substantial alterations in the wholesale value of the oil industry's products. Gasoline, normally the most profitable of the industry's four major volume products, which include kerosene, residual fuel oil and gas oil and distillates, has suffered the most severely.

The cumulative effect of these changes on the over-all value of all products was discussed in articles in the October 15 and 22 issues of The Oil and Gas Journal. Their effect on the products individually is shown in the accompanying figure which compares the wholesale value of these products in each of the first 9 months of 1942 with their average value for the last 6 months of 1941. The latter is used as a base since OPC directives on yields and OPA rulings on prices are apparently based on that period.

In the chart, the average for the last 6 months of 1941 is indicated by the horizontal broken (dot-dash) line. The effect of the factors mentioned above is indicated for each month by a divided column. Shading in the left side of the column indicates the effect of changes in district relationships, that is, a combination of revisions in yields and shifts in runs. Shading in the right side indicates the effect of changes in prices. The cumulative effect of these factors is indicated by the heavy solid line. In some instances they offset each other as is evident particularly in gas oil and distillate for the second and third quarters.

The general effect of these factors may be defined briefly as follows: Changes in yields have reduced the output of higher-value gasoline and increased the output of lower-value fuel oils. Shifts in the refining balance have reduced the proportion of runs to stills in the area of normally highest wholesale-product values (East Coast) and increased it in areas of lower-product values (California, Indiana-Illinois and Oklahoma-Kansas). Changes in prices, limited in their adverse effect to gasoline, have been most pronounced in the area of the largest volume of production (Gulf Coast).

Gasoline Suffers Most

As the accompanying chart shows, gasoline, the industry's major profit product, is the one which has suffered severely. The decline in the proportion of the value of gasoline to the value of all the products has been sufficiently severe to more than offset all appreciation in the value of other refinery commodities. The over-all value of gasoline at refineries in September was 9 per cent lower than its average for the last half of 1941. This is owing in part to the fact that a lower proportion of gasoline is being produced generally and in part to the reduction of output in areas of higher prices and increases in areas of lower quotations.

The effect of these changes has been greatest in two areas, the East Coast, which is the area of highest refinery prices, and the Gulf Coast, which is the area of greatest volume. In the last 6 months of 1941 these areas together ran more than 45 per cent of all crude oil processed in the United States, while they dropped to an estimated 37.5 per cent in the third quarter of 1942. Gasoline production in the East Coast area is estimated to be from 20 to 25 per cent less than in the final 6 months of 1941, and in the Gulf Coast area from 10 to 12 per cent.

The effect of price changes, however, has been the greatest influence in the reduction in the value of gasoline. Not only are OPA ceilings lower than the average prices for the last half of 1941 but in important instances current gasoline quotations are lower than permitted ceilings. A comparison of some average quotations for the last half of 1941 against existing ceiling prices for 72-74-octane gasoline follows: New York Harbor, 8.3 cents against 8 cents; Gulf Coast 6.3 cents against 5.8 cents; and Oklahoma, 6.2 cents against 6 cents. In California the average price of 65-octane gasoline in the last 6 months of 1941 was 7.1 cents and the ceiling is 7 cents. In the four districts mentioned, only the New York Harbor quotation is up to the ceiling level and, in the area which it represents gasoline production has been substantially reduced. In the Gulf Coast, where the greatest volume of gasoline is produced, current quotations are 0.2 cent under the ceiling, in the Group 3 area 0.1 cent, and in California 1.2 cents.

Since the first quarter of the year, changes in refining district relationships constituted the principal factor in keeping the value of kerosent above the base period, whereas price changes were responsible for holding up the value of gas oil and distillates. Shifts in runs away from the East Coast district, where the largest yields of gas oil and distillate are normally obtained, reduced the over-all value of these products, but the beneficial effect of price changes was sufficient to offset that reduction. The same factor that tended to adversely affect light burning oil also reduced the value of residual fuel, which, with no price change effect in September, was below the base period in that month.

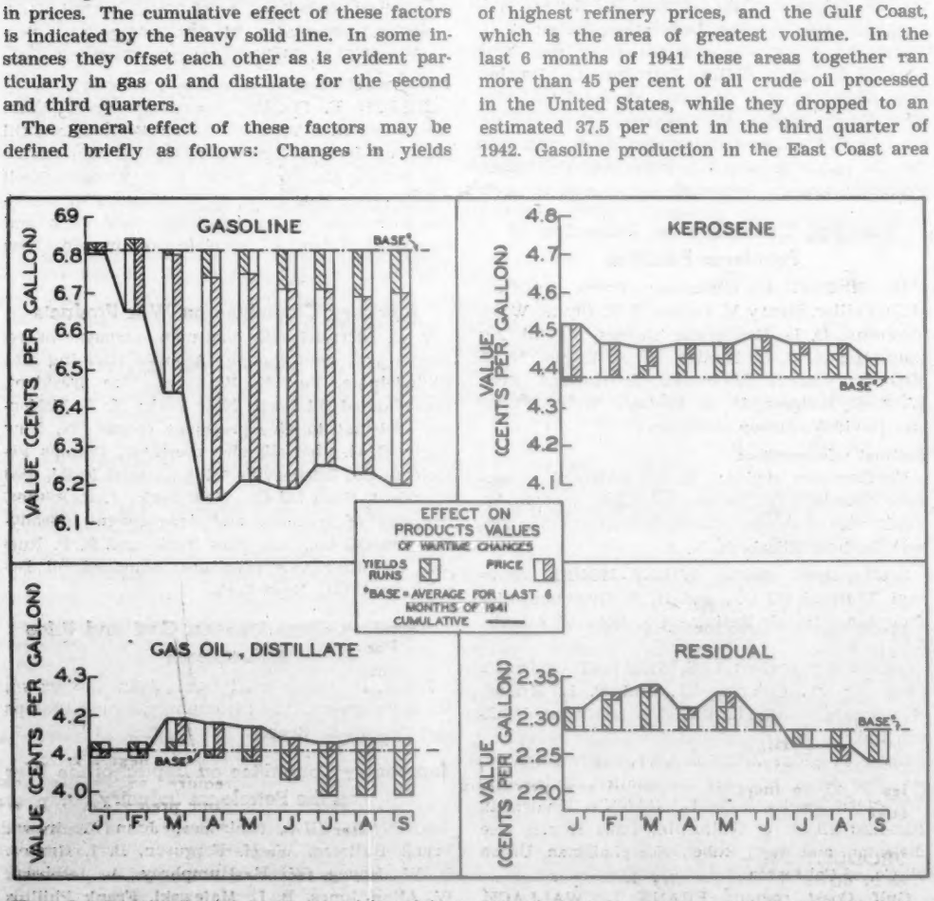


Chart showing the effect of revisions in yields, shifts in balance of refining among various districts and changes in prices on the four major refined products

Supreme Court Rules Drilling Contractors Are Engaged in Interstate Commerce

WASHINGTON, D. C.—The Supreme Court held that employes of a drilling contractor are engaged in interstate commerce, and as such subject to provisions of wage-hour law. In an opinion by Justice Murphy, the court held that Warren-Bradshaw Drilling Co. owed certain employes back pay and overtime pay. In connection with work done on some 32 wells in the Panhandle field.

The drilling company contended it had no reason to believe that the oil produced from wells drilled by it would go into interstate commerce, but court held "the record contains ample indication that there were reasonable grounds for petitioner to anticipate, at the time of drilling, that oil produced in the wells drilled, would move into other states, petitioner, closely identified as it is with the business of oil production cannot escape the impact of the act by a transparent claim of ignorance of the interstate character of the Texas oil industry."

Justice Roberts, in a dissenting opinion, said the majority holding would probably be applied to the labor of the man who made the tools, the sawyer who cut the wood incidentally used, and others whose work was as necessary to the production of oil as the driller's employes.

Canadian Operators Seek Boost

In a submission to C. R. Cottrelle, federal oil controller, the Alberta Petroleum Association has urged that an increase in the price of Alberta crude be authorized with a view to encouraging further development work and maintaining production.

PIWC Surveys Outlook for Supplying Enlarged Demand

(Continued from Page 59)

ators of petroleum truck transporters in order to offset Directive 57 and limitations imposed by the Office of Defense Transportation was requested by another council resolution. OPC and ODT have issued orders preventing the use of tank cars for movement of petroleum products distances of less than 200 miles and prohibiting the engagement of railroads for the movement of all automotive gasoline within District 2 and a few surrounding states. Inability of truck-transport operators to obtain tires from their local rationing boards threatens to so severely restrict distribution as to interfere with the war program.

Increase of the speed limit on petroleum-transport trucks to 45 miles an hour was also urged by the council as means of speeding distribution and, at the same time, as a fuel-conservation measure, the council resolved that the increased burden of distributing petroleum over longer highway distances could not be satisfactorily dispatched at the lower speed. The necessity of braking speeds on downgrades, the council resolution said, consumed more rubber than if tank trucks were authorized to travel at the higher speed of 45 miles per hour.

Demonstration of the tubeless tire before the council by John B. McGay, Tulsa, was enthusiastically received by the council. W. S. Farish, president of Standard Oil Co. (New Jersey), proposed that members of the council, the ODT and other industry and government agents concerned should make opportunities available to Mr. McGay for broad demonstration of his device. This tire was described in the November 5 issue of the Journal.

"The imposition of nation-wide rationing," the council's economics committee reported, "brings to a sharp focus the impending radical decline in total motor-fuel consumption throughout the country west of the Alleghenies. The reduction expected is calculated at 13 per cent compared with recent demand which has already reflected the effect of voluntary conservation. This reduction will be superimposed upon a situation in which demands for the other products are pressing upward. This situation obviously calls for a pattern of refinery output entirely different from that heretofore prevailing and applies to all areas in which rationing has not previously been in effect.

"The extent to which refinery yields must be adjusted in the various districts in order to create a balanced situation in terms of impending gasoline rationing call for a cut of 5.4 per cent in District 2; of 2.2 per cent in District 3 and 0.2 per cent in District 1 during the next 5 months. A slight increase is provided for District 4."

The committee inferred that refineries producing war materials should be considered in a separate operating category. It was pointed out that production of gasoline could not be materially reduced in refineries manufacturing aviation-fuel components, toluene and butadiene.

"The lack of balance," the committee declared in dealing with the war refineries, "will increase as more refinery facilities are installed for the manufacture of war products. The necessity will probably soon have to be faced of working out a compromise of sacrifice as between limited transportation and war-product supply.

"The adjustment in refinery yields necessary to support a balanced program is complicated by the necessity of maintaining full production of war products which require certain levels of crude runs and gasoline production."

This float, pictured in the Navy Day parade in Philadelphia, Pa., symbolizes the dominant overtone at this week's twenty-third annual meeting of the A.P.I., a determination to meet the fuel requirements for winning the war despite handicaps

This Week...

MARKETS.—Prospects of higher fuel-oil prices to East Coast consumers diminish as Price Administrator Leon Henderson opposes increase in rail rates . . . Supply situation on East Coast becoming more serious . . . Buyers of refined products combing sources of supply in Mid-Continent and Southwest for material . . . Markets generally firm to strong . . . Natural gasoline prices in Mid-Continent boosted another quarter cent . . . Wartime revision in yields, shifts in runs and changes in price depreciate gasoline values. . . .

TRANSPORTATION.—Proposed Tennessee Gas & Transportation Co. natural-gas line from South Louisiana fields to Tennessee and Alabama to make available additional 100,000,000 cu. ft. of gas daily to existing lines in Appalachian area to relieve threatened gas shortage . . . Plans completed by Lone Star Gas Co. to lay 82 miles of pipe line to bring additional gas to Dallas area from East Texas field. . . . Construction of feeder lines for Longview, Tex., terminal of War Emergency Pipelines, Inc., to start this week. . . .

REFINING.—Wright W. Gary, former director of the Refining Division of OPC, tells California natural-gasoline manufacturers that industry must step up production of unsaturates and concentrate on separation and purification of intermediate products. . . . Refinery operation in future to involve production of many products. . . . Higher freight rates threaten oil supplies of midwestern refineries. . . . Refineries asked to increase output of raw petroleum coke. . . .

PRODUCTION.—OPC estimate of 19,000 wells to be drilled in this country during 1942 is proving fairly accurate . . . Revised proration order for Hugoton field in Kansas establishes basis acreage unit of 160 acres and calls for factor of "deliverability" of gas . . . Redrilling program bolsters production of Oklahoma City field to meet increased crude demand . . . Engineers in East Texas field study methods for controlling salt-water production . . . Daily average crude-oil production drops 75,040 bbl. to 3,851,470 bbl. . . . Mississippi production declines 35 per cent since first of year.

MATERIALS.—New Controlled Materials Plan of War Production Board receives acclaim from Material Division of OPC. New procedures yet to be worked out.

AMERICAN PETROLEUM INSTITUTE.—Traditional ingenuity of oil men and close cooperation between industry and government should go long way in solving wartime problems, President Boyd proclaims. . . . M-68 will result in drilling 13,000 fewer wells in 1942, predicts OPC Director of Production Don R. Knowlton. . . . Job of protecting oil industry's facilities is up to industry itself, OCD official declares. Facility Security Division completing organization to aid industry. . . . War is causing many dislocations in natural-gas industry, says E. Holley Poe, OPC director of natural gas and natural gasoline. Problems to be overcome. . . . Pipeline industry is playing important part in country's war program, OPC Director of Transportation Parten states. . . . Deficit of more than 100,000 bbl. daily during the next 5 months in the petroleum supply required on the East Coast to meet rationed demand predicted by PIWC. . . . Internal-security program of Army calls for the most complete protection possible for oil industry facilities, Army officer tells A.P.I.

STATE CAPITALS...

CALIFORNIA

CALIFORNIA'S CRUDE-OIL production schedules for November provide for 738,000 bbl. per day of crude oil and 44,000 bbl. of other liquid products, including natural gasoline and distillate. The oil industry secured temporary relief from the dimout regulations in effect on the Pacific Coast under which a total of 3,000 watts of light for drilling rigs and 1,500 watts for each well being serviced, provided no light escapes above the horizontal plane of the fixture. In addition, the variance which expires November 25, unless sooner revoked, permits the use of light directed up into the sky during actual pulling of rods and tubing from wells, provided the wattage of the lights do not exceed a total of 200. The facility protection committee is at present engaged in drafting a recommendation for permanent variance which will probably be along the lines of the temporary concessions now in effect. In requesting the variance, the committee pointed out that under the terms of the existing proclamation safe and efficient conduct of drilling and producing operations at night were practically impossible. At present there are approximately 102 drilling wells in California that would be affected by the dimout order and in addition there are over 16,000 producing wells in the state, most of which operate at night without servicing but which might require lighting in an emergency. The defense board in granting the temporary variation from the existing order made it clear that lights must be shielded so no direct rays are emitted above the horizontal and that the order is subject to revocation at any time.

KANSAS

A REVISED PRORATION order for the Hugoton gas field in Kansas was issued last week, replacing the previous basic formula that had been in effect since January 30, 1940.

The basic acreage unit to be used in the proration formula was fixed at 160 acres. But in any instance where the size of the lease or the unitization of property will permit, the unit may be larger but in no case more than 640 acres. The Corporation Commission pointed out that 188 producers in the Hugoton field are located on 640-acre tracts and 84 on 160-acre divisions.

The other basic factor in the newly adopted Hugoton proration formula is "deliverability," which the commission describes as "the ability of said well to deliver gas against 80 per cent of the average field pressure."

The deliverability factor of each well shall be determined by test, consisting of a measurement of the rate at which the well is capable of producing gas and delivering it against a back pressure equal to 80 per cent of the average closed-in well-head pressure of the wells in the field expressed in pounds per square inch gage, and designated herein as the deliverability standard pressure. During the test the flow of the well shall be fed into a pipe line, the pressure in which is maintained at a point lower than the deliverability standard pressure, and the well gate shall be choked to maintain a back pressure on the well, determined by deadweight gage equal to the deliverability standard pressure until the rate of flow of gas from the well measured by approved meter varies not more than 1 per cent in 1 hour. The rate of flow so measured at the end of the hourly period, expressed in thousands of cubic feet per day, shall constitute the deliverability factor of the well.

To determine a well's quota for a given proration period, determine first the proration factor for the field by dividing the total field allowable for such period by the sum of the products of deliverability times the acreage factors of all the wells in the pool, then multiply the field proration factor by the product of the deliverability times acreage factor for the well. The result reached by this calculation shall constitute the well's allowable in cubic feet which it may produce for such proration period.

Provision is made for dividing the year into two basic proration periods. The first period shall extend from October 1 to March 31 and the second from April 1 to September 30, both inclusive.

The Kansas portion of the Hugoton field consists of an area approximately 65 miles long and 40 miles wide. Approximately 327 commercial gas wells have been drilled in the field and more than 200 billion cubic feet of gas have been withdrawn from the common reservoir. The developed acreage held by production totals 155,320 acres compared with an estimated proven total of 1,500,000 acres. Twenty-two of the field's wells are not connected to pipe lines and are not producing and have not produced in the past. Some of the closed-in wells have been completed for 8 years. The market demand for Hugoton gas, the Corporation Commission found, is approximately 100,000,000 cu. ft. daily.

TEXAS

ENGINEERS representing operating companies in the East Texas field met with engineers of the Railroad Commission in an open hearing at Kilgore November 5 to study methods for controlling salt-water wells in the field. Engineering data upon which to base a proposed commission order to permit transfer of allowables of wells producing excessive salt water to other wells was assembled. This will be presented for discussion at a state-wide hearing to be held in Austin.

Data were submitted to determine how the amount of oil a well produces gradually decreases after the well starts producing more than 100 bbl. of water daily and how long before the well has to be abandoned. Action to control the salt-water production is being taken to forestall possible federal control of the field.

MONTANA

ONLY ONE CHANGE affecting the Montana oil industry was made at the election last week. That was the election of Leonard C. Young, Superior miner, as a member of the Montana Railway Commission, succeeding Horace F. Casey, Butte. Mr. Young was a member of the commission at the time when pipe-line rates were established in the Kevin field.

NEW GOVERNORS OF OIL-PRODUCING STATES

Robert S. Kerr, Oklahoma City, Okla., and Andrew F. Schoeppel, Topeka, Kans., were the successful gubernatorial candidates in last week's election. Mr. Kerr is president of Kerlyn Oil Co. and affiliated operating and drilling concerns. He has served several terms as president of the Mid-Continent Oil and Gas Association. Mr. Schoeppel, former member of the Kansas Corporation Commission and that state's representative on the Interstate Oil Compact Commission, has been active in administrative affairs of the Mid-Continent oil industry for several years

the OIL AND GAS JOURNAL

PRODUCING REFINING NATURAL GASOLINE PIPE LINE

Published weekly by The Petroleum Publishing Company at Tulsa, Oklahoma

Time for a Halt

A reader suggests that we take time off and analyze how far down the road of a socialized industry the oil business has gone as we approach the first anniversary of the war. Our reader concedes that as a war expedient part of what has happened is justified, part is not, and all of it, he is sure, is dangerous unless the road is kept open so that this industry can return quickly when the emergency is over.

Operators have accepted many wartime regulations without question as being an inevitable development of the acute transportation shortage that arose early in the year when tanker shipments were reduced to a small fraction of normal.

This has brought practically complete control and a general pooling of all transportation facilities. War agencies have projects under way which will mean that the Government will have in excess of 100 million dollars invested in pipe lines within a few months. It is also rapidly becoming a major owner of tankers.

What has happened in transportation is rapidly being duplicated in refining. Operators are being told how to operate their plants and where and to whom part or all of their products are to be shipped. When the aviation gasoline, synthetic rubber and toluene plants are completed, the Government will have around three-quarter billion dollars invested in the industry's manufacturing facilities.

In marketing the Atlantic seaboard operations furnish as good an example of business regimentation as will be found anywhere. Under a directive, government agencies have control over transportation and sources of supply in that area and are now engaged in pooling wholesale distribution facilities with authority to establish standard specifications for certain products. Under this program, which apparently is to be extended to cover the entire country, marketing competition is ended and control over operating procedure, in effect, is complete.

It should also be kept in mind that all this is coupled with price ceilings, the application of rationing where it is considered necessary, and control over supplies and equipment with which to operate.

Now there are those at Washington who want to go the remaining distance. They are talking seriously of taking over the industry's exploration through the granting of subsidies and through the control of wildcat drilling. While insisting that crude-oil prices generally remain at prewar levels, they have indicated their approval of selective advances whenever in the opinion of government experts they are needed by operators.

The test applied by the oil business to each of the new controls has been "will it serve the war effort?" While it has not been clear in several instances that the industry's numerous and essential contributions to the war would be advanced by what has been done, operators generally have supported the rulings.

Now it is apparent that a halt must be called. The plans covering exploration and production practices in the fields go to the roots of the industrial tree. They can quickly nullify everything the industry did in preparation before the war started and cancel the accomplishments of those at Washington who have a sympathetic understanding of how this industry must operate under a war economy.

Due to the nature of the oil business each application of bureaucratic regimentation begets several more controls. The end would be all controls and no business. The aim of Government should be to apply emergency regulations only when there is no other way out and then temporarily with every encouragement given for normal functioning, whence came this industry's preparedness and which is this nation's only guarantee of oil until the war ends.

Controlled Materials Plan Is Generally Acceptable to OPC

By HENRY D. RALPH

WASHINGTON, D. C.—Broad aspects of the new Controlled Materials Plan, announced 10 days ago by the War Production Board, this week received acclaim from the Materials Division of the Office of Petroleum Coordinator, although there are dozens of new procedures to be worked out in the next few weeks so that OPC can swing into the new setup.

"One big advantage of this plan," one high-ranking Materials Division official said, "is that everyone in the oil industry will know where he's going and what materials and supplies he'll get at all times."

While the new plan has not been fitted into the OPC organization as yet, the Materials Division is studying it from the standpoint of all operating branches, and it was indicated that it may be the end of this week or the first of next before any definite procedures can be ar-

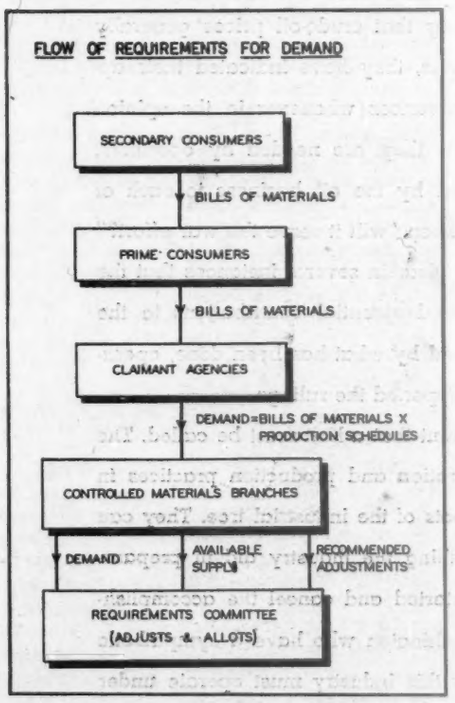


Chart C

ranged, or the whole order analyzed as it applies to the oil industry.

At first it appeared that all oil requirements would have to go through Leon Henderson's Office of Civilian Supply, and it still appears that way. However, it is said that some readjustments may be made to break down the nonclaimant agencies among the so-called "claimant agencies," so that the oil requirements might not have to go through the Civilian Supply organization.

Oil-industry representatives in Washington were concerned over the apparent provision of the order that all not represented on the so-called "claimant agencies" group would be subject to allocations through Civilian Supply. However, OPC officials say this is still to be decided.

Of the two types of materials set up under the order, there are the "A" and "B" classifications. Many petroleum-industry materials are in the second group, which must (under present programming) be applied for through the Office of Civilian Supply. These are, to cite but a few: bolts, nuts, rivets, screws, and washers; containers; heat exchangers; instruments for indicating, regulating, and recording temperature, pressure flow, liquid level, humidity, movement, time, and electrical quantities; motors, electric, and motor-generator sets; petroleum machinery; power boilers and auxiliary equipment; pumps, power driven, except measuring and dispensing pumps; valves; welding rods and electrodes.

Under the CMP, War Production Board will bring about the adjustment of production to programs to conform to supply, and allot certain materials to different government agencies representing all military and essential civilian requirements.

When the plan is fully in effect, the mills and factories producing controlled materials which, for the moment, include steel, copper and aluminum, but to which others may be assigned later, will not be allowed to fill any orders except against allotments made under CMP.

Of interest to the oil industry is the fact that separate provisions for construction and repair and maintenance materials are set forth.

Appropriate Industry Branch

As identified in the description, an "appropriate industry branch" includes the OPC, but at the same time, the order asserts that "all directions to controlled materials producers affecting production and distribution of controlled materials shall be issued by and through, and only by and through, the Controlled Materials Branches, except as may be ordered. . . ."

To as great an extent as possible, according to WPB, all industry branches, including OPC, will follow a regular pattern, and many of the functions of the director general for operations will be decentralized and assigned to branches, making them responsible for all operating phases such as the execution of programs, policies and procedures established for the resources under their jurisdiction.

What OPC wonders about is the proviso that the WPB will maintain its connection with each industry group through "active industry advisory committees" assigned to each branch. Will this mean, they wonder, if WPB technicians are to take over all requests on the part of the oil industry.

The eight "claimant agencies" set up under the new plan are: War Department, Navy Department, Maritime Commission, Aircraft Scheduling Unit, Office of Lend-Lease Administration, Bureau of Economic Warfare, and Office of Civilian Supply.

There is no mention of the Office of Petroleum Coordinator, although many officials have asserted the opinion (and among them Judge Cole, former chairman of the House interstate commerce committee's oil subcommittee) that oil is probably much more important to the winning of the war than any other product.

This method of distributing materials is, in effect, "vertical allotment," WPB explained in announcing the program. So far as controlled materials are concerned, it will gradually replace the present priority system, including the Production Requirements Plan, which is on a horizontal basis.

Under PRP each firm, large or small, prime contractor or subcontractor, submits his own requirements to WPB for approval, and receives an individual authorization to obtain materials.

Under the new CMP, prime contractors will prepare and submit a breakdown of all materials

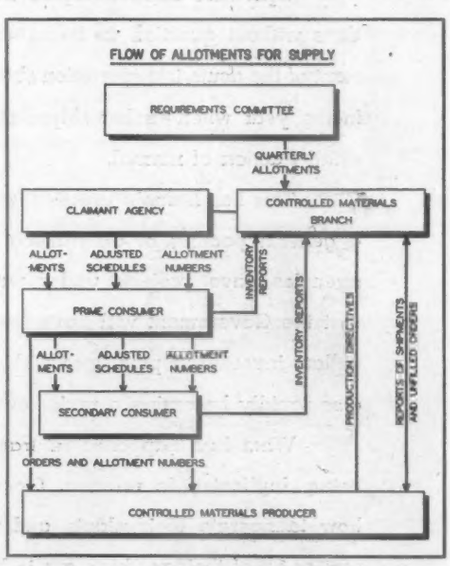


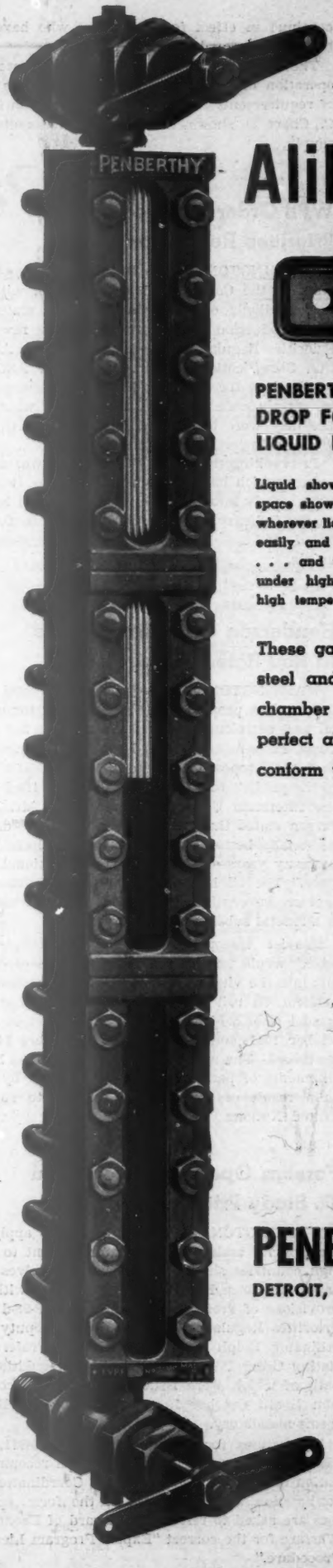
Chart D

required for the approved end products on which they are working. The breakdown will comprise a "bill of materials" specifying not only what materials are required, but when they must be received to carry out the authorized program.

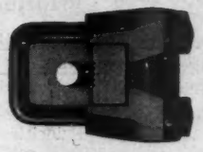
In making up his bill of materials, each prime contractor will include both the materials he puts into production himself, and those needed by his subcontractors and their suppliers. The bill of materials will cover requirements not only for controlled materials but also for other scarce materials listed in the outline of the plant.

The bills of materials obtained from prime contractors will be assembled by each claimant agency and submitted to the WPB requirements committee, and to the respective controlled-materials branches, which will make the necessary adjustments to bring the whole program into balance with available supplies.

When requirements have been brought into balance with supply and the programs of the



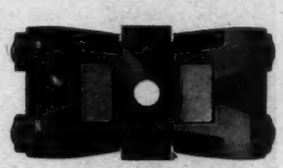
Alike in Quality



PENBERTHY *Reflex*
DROP FORGED STEEL
LIQUID LEVEL GAGES

Liquid shows black — empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.

These gages are made of alloy temperature resisting steel and are the highest quality throughout. Liquid chamber is made from a solid block of steel to assure perfect alignment and rigidity. All Penberthy gages conform with A.P.I.-A.S.M.E. requirements.



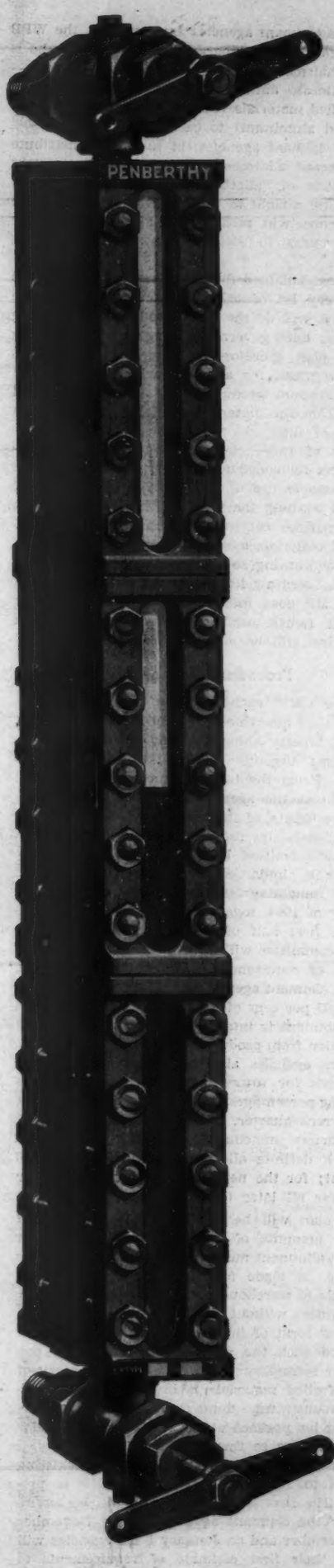
PENBERTHY
Transparent
DROP FORGED STEEL
LIQUID LEVEL GAGES

Used to observe color and density of liquids under high pressures, and/or temperatures. Construction is exceptionally rugged . . . similar to Reflex types.

PENBERTHY INJECTOR CO.

DETROIT, MICHIGAN • Canadian Plant; Windsor, Ontario

PENBERTHY PRODUCTS



various claimant agencies are approved, the WPB vice chairman on program determination—who is also chairman of the requirements committee—will allocate authorized quantities of the three controlled materials (carbon and alloy steel, copper and aluminum) to each.

The claimant agencies, in turn, will distribute these broad allotments among prime contractors by means of "allotment numbers," which will constitute a right to receive delivery. The prime contractors will pass on the allotment numbers as necessary to their subcontractors and suppliers.

It was explained that the aim of the plan is to use every bit of critical material in the place where it will do the most good toward winning the war. Each governmental agency participating in the plan, therefore, is being required to present programs for approval which will lead to the maximum production of the things needed most from the materials available in any given period of time.

Each of these claimant agencies will be responsible for constructing a program making the best possible use of the materials allotted to it toward winning the war. At the same time, the plan provides centralized control over the division of materials among the agencies and appropriate accounting so that no agency nor contractor can overdraw its allotment.

As CMP goes into effect, the job of cutting out all nonessential production, military and otherwise, will be completed.

Procedure Under CMP

Under CMP, each claimant agency will program the quantities of end products—guns, planes, Liberty ships, railroad cars, bedsprings, etc.—most urgently needed for each quarterly period. From the bills of materials for each of these items the agency will make up a consolidated estimate of its total requirements. These detailed estimates for the second quarter of 1943 must be submitted by January 1, 1943. At the same time, similar estimates must be submitted for the remaining quarters of 1943 and the first quarter of 1944, together with general estimates for the first half of 1944, so that the requirements committee will have at all times a general picture of requirements 18 months in advance.

Each claimant agency may allot for each month up to 105 per cent of its monthly allotment. This over-allotment is intended to stimulate increased production from producers of controlled materials. Claimant agencies also are authorized to make allotments for future quarters on the basis of declining percentages of allotments established for the current quarter. These percentages are: for the quarters immediately following the one for which a definite allotment has been made, 80 per cent; for the next following quarter, 60 per cent; for all later quarters, 40 per cent.

The plan will be flexible enough to permit limited amounts of material to be given out without allotment numbers. Special provision, for instance, is made for allotments of controlled materials to warehouses so that they may handle small orders without allotment numbers.

A new form of inventory control is to be established with the requirement that every primary or secondary producer whose inventory of all controlled materials is in excess of a specified amount must submit an inventory statement showing his position at the end of each calendar quarter not more than 15 days later.

A time table for the transition from existing systems to full operation of the CMP is provided. The first bills of materials will be assembled by the claimant agencies during November and December and on January 1 the agencies will submit their first estimate of requirements to the branches handling controlled materials.

By January 15 the controlled materials branches will have analyzed the requirements and made preliminary reconciliation to the extent possible between requirements and supply. At the same time, the claimant agencies and prime consumers will be developing information necessary in making final allotments.

Second Quarter Allotments

On February 1 the requirements committee will make allotments of controlled materials to claimant agencies for the second quarter of 1943. During February and early March, distribution of allotments will be made by claimant agencies to prime consumers, who in turn will divide allotments with their secondary consumers and suppliers.

By March 15 users of controlled materials will have placed authorized orders for April delivery and for later months, as approved. Subsequently the controlled materials branches will watch placement of orders on mills and mills' shipments, and give assistance in placing orders to authorized users of controlled materials who are unable to obtain mill acceptance of authorized orders.

On July 1, CMP will be in full operation. Until that time existing procedures, including preference rating orders and PRP certificates and individual material allocations under M orders will continue in effect for consumers who have not been able to qualify under CMP.

The two accompanying charts illustrate the operation of different phases of CMP. The flow of requirements for demand is pictured on Chart C. Chart D shows the flow of allotments for supply.

Tulsa Oil-Man Senator Receives Hundreds of Congratulatory Messages

E. H. Moore, independent operator of Tulsa, was receiving congratulations from a myriad of friends and well wishers this week after winning the election as United States senator from Oklahoma. A life-long Democrat, Mr. Moore ran on the Republican ticket, and emerged victorious over Josh Lee, a New Deal Democrat.

Mr. Moore came to Oklahoma in 1901. He quickly became an oil man, and when the Fitts pool, of which he was one of the discoverers, came in, built a model camp for his workmen at Fittstown. He equipped the houses of his workmen with electric refrigeration and other modern conveniences.

Mr. Moore has an enviable record as civic leader and publicity-dodging philanthropist. He is the head of the company which bears his name.

WPB Order Revokes Priorities Regulation 10

WASHINGTON, D. C.—Shortly after announcement of the Controlled Materials Plan, with its new methods of governing flow of materials, War Production Board issued an order revoking Priorities Regulation 10, which set up the Allocation Classification System. Under the ASC, all applications for materials had to be accompanied by certain code numbers, designating what end use they were to be used for, what government group, or what private industry group.

In revoking the order, WPB said it was a procedure which has not been "justified by final results." Only industry still under ASC will be the copper industry, which must still furnish the detailed end-use information the old system requires.

Henderson Opposes Increase In Rail Rates on Petroleum

WASHINGTON, D. C.—Entering a formal protest against proposed higher rail rates for crude oil and petroleum products shipped to the East Coast, Price Administrator Leon Henderson warns that the proposed increase will add $50,000,000 to the public's fuel bill. In the protest, filed with the Interstate Commerce Commission, Mr. Henderson stated that "the carriers involved—are in financially better condition than they have been in many years—and do not need additional revenue." The oil industry cannot bear further increases, he continued, and the only alternatives is a federal subsidy or higher price.

Heavier transportation costs, Mr. Henderson added, would tend to restrict movement of crude oils into the vital industrial East, now almost dependent on rail shipments. He asked that the special rates which were put into effect in September 1941, and which expire November 14, be continued. The special rates were based on large shipments of petroleum and oil products by rail as a result of diversion of tankers to supply United Nations.

Foreign Operators Are Urged To Study Priority Provisions

WASHINGTON, D. C.—Oil operators applying for priority assistance for materials sent to foreign countries should familiarize themselves not only with Form PD-311, revised, but also with all provisions of Preference Rating Order P-98-d and Priorities Regulation 9, as amended, Deputy Coordinator Ralph K. Davies advises. Preference Rating Order P-98-d and Priorities Regulation 9, both of which were issued by the War Production Board October 1, make the use of PD-311 forms mandatory.

Instructions for filling out Form PD-311, revised, are being issued by WPB upon recommendation of the Office of Petroleum Coordinator. In conjunction with filling out of the form, operators are asked to refer to the Board of Economic Warfare for the correct "Export Program License Procedure."

Cashing in on foresight

Strong recommendations have been made by leaders of the industry and the federal oil agencies that refiners throughout the country analyze their facilities to determine how they may mesh operations more completely into the war production program—H. STANLEY NORMAN in OIL AND GAS JOURNAL, August 6, 1942 issue

Refiners *are* analyzing their facilities and many are getting advice and help from Universal as they have been doing for years

Every unit ever designed by Universal engineers was laid out with two major objectives in mind

First, to produce the highest yield of the best products under existing conditions of market and of crude supply;

Second, to allow for future changes to be made at the smallest possible expense for new materials and with the least possible disturbance of operations

By reason of that foresight, more than one Universal unit is being converted to "mesh operations more completely into the war production program," thus saving scarce materials of construction—and saving time

OIL IS AMMUNITION—USE IT WISELY

Universal Oil Products Co
Chicago, Illinois

Dubbs Cracking Process
Owner and Licensor

THE REFINERS INSTITUTE OF PETROLEUM TECHNOLOGY

Our Promised Land ... OR THEIRS?

LAND OF LUXURY ONCE. Land of hard work and willing denial now. But still OUR land!

To keep it ours, chemistry's miracles go to war. Cooper-Bessemer compressors forge hydrocarbons into weapons . . . they help make aviation gasoline, high explosives, synthetic rubber. They handle natural gas, helium, hydrogen, chlorine, acetylene.

This big 600 hp Type G-MV unit does double duty —driving ammonia compressors, as well as compressing natural gas.

Cooper-Bessemer is building nearly twice the compressor horsepower of last year. 1943 will double that production. Not only more, but better compressors — with ingenious automatic control of speed, temperature and pressure! With such machines, the petroleum and natural gas industries are forging thunderbolts to destroy those enemies who would make our land their own.

After Victory, better Cooper-Bessemers can help produce in plenty those wonder materials that come from oil and gas . . . to fulfill the rich promise of this Chemical age.

Cooper - Bessemer

MOUNT VERNON, OHIO AND GROVE CITY, PA.

New York Washington Bradford, Pa. Parkersburg, W. Va. Gloucester, Mass.
Houston, Dallas, Greggton, Pampa and Odessa, Texas
Tulsa Shreveport St. Louis Los Angeles Seattle, Wash.

Natural Gasoline's Part In War Is Discussed at Annual C.N.G.A. Meet

By L. P. STOCKMAN

LOS ANGELES, Calif.—Recognizing the absence of technical men, now in military service, and the necessity of reducing all automobile travel to a minimum, directors of the California Natural Gasoline Association some time ago decided to restrict the seventeenth annual fall meeting to a ½-day session with a banquet in the evening at the Biltmore Hotel in Los Angeles, November 6. This plan was carried out and consequently the number of papers was much smaller than usual. The attendance was also much smaller although all sections of the state were represented. The technical committee of the association held a business meeting at a morning session preceding the main meeting in the afternoon. At the technical meeting in the morning a paper on the infrared spectraphometer developed by Shell Development Co. was presented in person by Dr. Robert Brattain, who came down from his office at the Shell laboratory in Emeryville. The speaker discussed the application of the spectraphometer to butane mixtures and its possible application to other hydrocarbon mixtures as well as one of its principal uses, the analysis of B-B mixtures in refinery alkylation processes. The apparatus was available for inspection and its operation was explained by the author by a series of slides and detailed visible inspection. The morning session of the technical committee was open to all members and guests and a number heard this paper.

Holds Key to Future

Wright W. Gary, recently director of the Refining Division of OPC and lately called back to Washington to join the deliberations of the Baruch committee, now president of Filtrol Corp., opened the afternoon session with a talk on "Role of the Natural Gasoline Industry in the Nation's War Effort." Mr. Gary declared that in his judgment the natural-gasoline industry held the key to the future and that the industry should try to step up the production of unsaturates and to concentrate on separation and purification of intermediate products. The speaker suggested increasing the number of products made and opined that refinery operation in the future would involve the production of many products. The oil industry is going chemical, according to Mr. Gary, and synthetic rubber is here to stay in one form or another. The automobile of the future will require a more advanced grade of motor fuel and the outstanding development during the war period to date is the development and greatly stimulated production of aviation gasoline. Production of aviation gasoline has already shown an increase of over 100 per cent and, strange as it may seem, aviation gasoline is not gasoline at all but is a synthetic chemical. Not long ago butane was only considered as a gas until the liquefied petroleum-gas industry developed an outlet which today is jeopardized. Mr. Gary was of the opinion that propane would gradually take the place of the present butane-propane mixture but the liquid petroleum-gas business should be greatly concerned over future prospects.

The future of the natural-gasoline industry depends upon how many new different products and lower molecular hydrocarbons will be produced. New plants specializing in the development of additional chemicals from hydrocarbons will probably be located in the various fields rather than at refineries. This is particularly true where natural gas is treated or processed as excess gas or gas resulting from processing operations can be reinjected into the formation. This thought appears to coincide with the opinion of Dr. Linford, who stated in his paper that large petroleum-chemical industries can and undoubtedly will be built around basic processes in the not-far-distant future, and that while commercial applications of various processes have been developed to a limited degree, in no case have their full possibilities been exploited.

Meeting Committee

The main session of the meeting convened with W. W. Robinson, Jr., of Texas Co., presiding in his capacity as president of the association for the 1942-43 term. R. W. Heath is vice president and George L. Tyler secretary-treasurer. The 1942 fall meeting committee consisted of D. E. McFaddin, of Union Oil Co., chairman; R. R. Crippen, Texas Co.; Ben C. Dumm, Allied Supply Co.; M. W. Kibre, General Petroleum Corp.; J. H. Kunkle, Fluor Corp., Ltd.; Randall Maas, General Petroleum Corp., and J. B. Taylor, of Signal Oil & Gas Co. Hooper Linford's paper on the "Chemical Utilization of Natural Gas and Natural Gasoline Hydrocarbons by Oxidation," presented in slightly abridged form on Page 71 of this issue, proved to be outstanding. Mr. Linford, in explaining the scope of his paper, called attention to the fact that natural gas and natural gasoline are composed primarily of mixtures of the simpler and lower molecular weight paraffin hydrocarbons and although the paraffins were originally thought to be inert chemically, they are actually chemically active and are readily converted into various widely different chemical derivatives.

W. W. Robinson, Jr., Texas Co., president of the California Natural Gasoline Association for 1942-1943 term

Alexander Macdonald, deputy regional director, Los Angeles area, War Production Board, spoke on "Steel Allocation Problems in the Oil Industry." The author emphasized that the WPB's conception of the priorities system or of the allocation of materials is based solely upon what end products are to be created by the materials. A gallon of gasoline is not judged by its monetary value but only by the critical materials required to produce it and the relative necessity for gasoline in the war effort. The so-called controlled materials plan which recently came into being stipulates that the oil industry is not immediately affected. This is because that industry is already being dealt with substantially on an allocation basis.

Effect on Industry

The controlled materials plan is nothing more or less than the application to all industries of the present allocation system in effect with respect to the oil industry. It will, however, indirectly affect the oil industry because it affects the manufacture of equipment. The wise operator, Mr. Macdonald warned, will attempt to anticipate his needs of those items affected well in advance because under what might be called a scheme of rationing raw materials to industry, he will no longer be able to pick up the telephone and order a pump or other material whenever it is needed.

The oil industry, according to the speaker, will obtain more steel than some industries and less than others but it can be sure it will not obtain all the steel it needs. The oil industry was warned that it must state fully all conditions affecting priorities or deviations from M-68 and its amendments and to devise as many ways as possible to operate with a minimum of steel. None of the 232 major industries in the country is getting all the materials asked for and there is no prospect of increasing allotments as long as critical materials are needed for the war effort.

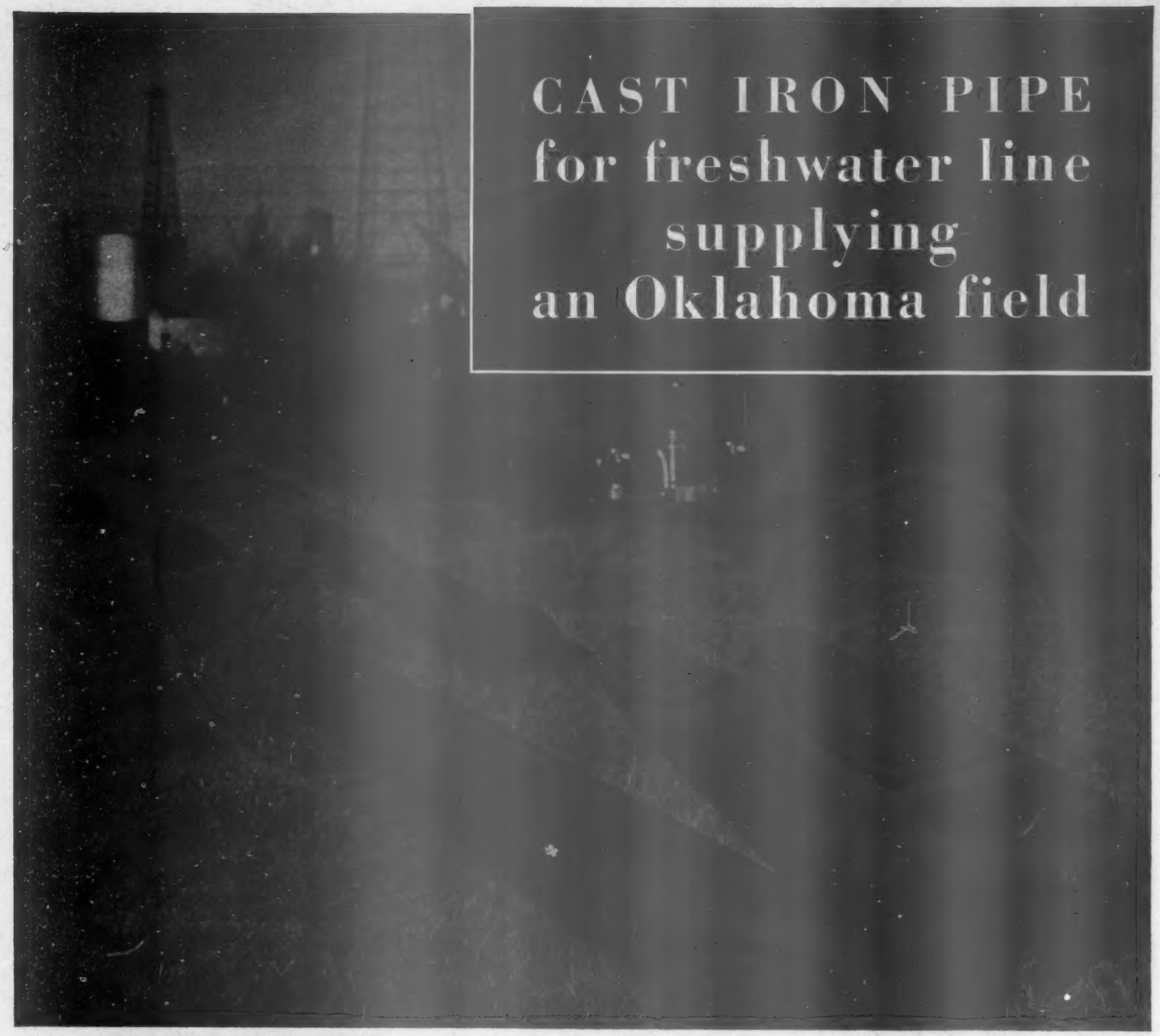
The controlled materials plan will affect steel, copper and aluminum, basic requirements of the oil industry. When this plan is in operation, the mills producing controlled materials will not be allowed to fill orders except against allotments made under the plan. During the transition period, until July 1, 1943, the preference-rating system will take care of those manufacturers who do not receive their allotments in time, but allotments for a given month will be filled ahead of other orders bearing preference ratings.

•

Order Prohibits Production of Oil-Well Pumping Units

WASHINGTON, D. C.—The production of oil-well pumping units, except for certain parts, is entirely prohibited under an order issued by the War Production Board November 5.

The only exceptions are brackets, cranks, equalizers, pitmans, reduction gears and case, saddle bearings, steel pin connections, washers. Also exempted from the order are parts for maintenance and repair and screws, nails, rivets, bolts, wire, strapping, and small hardware for joining or other similar essential purposes.



CAST IRON PIPE for freshwater line supplying an Oklahoma field

CAST IRON PIPE

For Longer Life and Economy

IN a wide range of applications in the petroleum industry over a period of years, cast iron pipe has consistently delivered *maximum resistance to corrosion per dollar of cost.* We refer, of course, to *ultimate* cost, figured by duration of service. Longer life, through greater resistance to corrosion, makes cast iron pipe economical even when its first cost is higher. Cast iron pipe is made in bell-and-spigot, plain and threaded ends and flanged types, or with stuffing-box mechanical joints, in diameters from 1¼ to 84 inches. Address inquiries to the Cast Iron Pipe Research Association, Thomas F. Wolfe, Research Engineer, 1015 Peoples Gas Building, Chicago, Illinois.

Oxidation Methods for Chemical Production from Light Hydrocarbons

By HOOPER LINFORD
Union Oil Co.

C. N. G. A.

This is a slight condensation of a paper presented before the seventeenth annual fall meeting of the California Natural Gasoline Association, Los Angeles, November 6, 1942, entitled "Chemical Utilization of Natural Gas and Natural Gasoline Hydrocarbons by Oxidation." The author is research chemist with Union Oil Co.

WHILE an appreciable development in the manufacture of organic chemicals from light petroleum paraffin hydrocarbons as raw material has occurred in this country during the last two decades, only the surface of this amazingly prolific field for chemicals and industrial and commercial products has been scratched. Products so far made in commercial or at least experimental quantities include alcohols, aldehydes, and acids (via both straight oxidation, and esterification hydrolysis routes) alkyl halides and polyhalides, ketones, esters, aromatics and allied products. More recently the utilization of light hydrocarbons as sources of synthetic-rubber intermediates, emergency requirements for military products such as toluene, etc., have focused attention anew on petroleum and natural gases as a storehouse of raw materials for chemical syntheses.

Data on the amounts of these light hydrocarbons actually or potentially available are important in considering this field. According to Bureau of Mines reports, in 1939 some 3½ trillion cubic feet of natural gas (100,000,000 tons) was produced in the United States. Processing of this total production should yield about 9,000,000 tons of natural gasoline. In 1941, 2,696,568,000 gal. of natural gasoline was produced, or 7,550,000 tons. Estimates for propane and butane production in 1941 place these figures at 102 million gallons of propane, 92 million gallons of butane and 89 million gallons of mixed propane-butanes.

By the pyrolysis of these light natural-gas hydrocarbons (methane to pentanes and higher), carbon, hydrogen, olefins and various liquid products are formed, with molecular structures built during pyrolysis which yield aromatics and other more complex hydrocarbons. Olefins may be converted later to alcohols by alkyl sulfate formation and subsequent hydrolysis. Butadiene is also formed by pyrolysis of light hydrocarbons and becomes one of the intermediates for synthetic rubber.

Halogenation, Oxidation Produce Chemicals

Halogenation of paraffins yields organic chlorides such as chloroform, $CHCl_3$, carbon tetrachloride, CCl_4, which may be converted to the refrigerant "Freon," CCl_2F_2 by interreaction with antimony trichloride. Mixed amyl acetates, used as lacquer solvents, are manufactured by chlorination of pentanes and hydrolysis to the alcohols which are employed to esterify acetic acid.

Oxidation produces alcohols, aldehydes, acids, ketones, esters, and carbon and hydrogen. The majority of these reactions may occur in the same oxidation step, although careful control of reaction conditions will guide the operation to produce a major portion of only one or two products. Formaldehyde, used as a disinfectant and in synthetic resin production, is formed by controlled oxidation of methane, during which methyl alcohol is also formed. Acetaldehyde and acetone may be prepared by oxidation of hydrocarbons consisting chiefly of ethane. Because of the usefulness of these products in the plastics industry as intermediates, and in other industries as solvents, etc., many believe that the plants now being built for war emergency exploitation of natural gas will be able to compete with the operationally more expensive synthetic processes after the war is concluded.

Methods which have been employed for controlling the oxidation reaction are, briefly: (1) the use of small proportions of oxygen or air, i.e., low oxygen to hydrocarbon ratios; (2) the use of short reaction times followed by immediate quenching of the reaction products, and (3) the use of catalysts to direct the oxidation or to allow the reaction to take place under less severe conditions of temperature and pressure than would be required without catalysts.

Methane

Methane, the simplest hydrocarbon compound, is the main constituent of natural gas. It is the most difficult to oxidize of any of the paraffins and, in this case, the intermediate oxidation products of methane are all far more susceptible to oxidation than methane. For this reason it is particularly difficult to control the oxidation reaction in such a manner that carbon dioxide and water are not the only products.

Padovani and Franchetti[1] found that the reaction to form carbon monoxide and hydrogen (Reaction 5) takes place with good yields over a nickel catalyst at temperatures of 1,560°-2,190° F., whereas Wiezevich and Frolich[2] found that methane reacted with air at 930° F. under a pressure of 135 atm. (about 2,000 lb. per sq. in.) to give methanol, formaldehyde, and formic acid. At temperatures above about 930° F. the reaction tended to form carbon oxides. Operating at the lower temperature these investigators found that the ratio of production of methanol to formaldehyde was between three and eight parts of the former to one of the latter, indicating that the conditions employed favored reaction (1). (Fig. 1.)

Fig. 1—Reactions between methane and oxygen

1. $CH_4 + O = CH_3OH$	Methanol
2. $CH_4 + 2\,O = CH_2O + H_2O$	Formaldehyde
3. $CH_4 + 3\,O = HCO_2H + H_2O$	Formic acid
4. $CH_4 + 4\,O = CO_2 + 2H_2O$	Carbon dioxide
5. $CH_4 + O = CO + 2H_2$	Carbon monoxide and hydrogen

The work of Wiezevich and Frolich was carried out on a sample of methane containing small percentages of ethane. It was pointed out by these authors that in experiments conducted with a sample of methane containing only 0.36 per cent of ethane slightly higher temperatures were required (970° F. or higher) to effect oxidation and most of the oxidation products were carbon oxides and water. However, small amounts of methanol, formaldehyde, and formic acid were obtained.

Burke and Fryling[3] oxidized methane with 50 per cent by volume of air at temperatures of 390° to 930° F. and pressures of 200-1,750 lb. per sq. in. without the use of catalysts and they obtained primarily aldehydes and acids. On the other hand Paris[4] found that by oxidizing methane using low oxygen to hydrocarbon ratios under high pressures the reaction leading to the formation of methanol was predominant. Although temperature did not appear to be as important as pressure in directing the reaction it was found that maximum yields of methanol were obtained at about 840° F.

Ethane

The second member of the paraffin series of hydrocarbons, ethane, is appreciably more easily oxidized than methane, but still less readily attacked by oxygen than the higher members of the series. Ethane is found in natural gas in amounts varying from 0 to about 25 per cent or even higher depending on the source of the gas.

Newitt and Townend[5] found that ethane could be oxidized at 520° F. under 100 atm. pressure with the production of rather large proportions of ethanol and methanol and smaller proportions of the corresponding aldehydes and acids. Although data regarding the percentage of ethane oxidized per pass through the reaction zone are not available, recalculation of the yield data presented by these investigators indicates that by completely oxidizing 1,000 cu. ft. of ethane gas (about 84.6 lb.) they would be able to produce 103 lb. of liquid products. Data regarding the yields of the various oxidation products of ethane are shown in Table 1.

TABLE 1—PRODUCTS OF THE PARTIAL OXIDATION OF ETHANE

(Pressure, 100 atm.; temperature, 520° F.)

Product—	Production/1,000 cu. ft.* (84.6 lb.) ethane consumed: Weight (lb.)	Volume (gal.)
Ethanol	52.5	8.0
Methanol	28.9	4.3
Acetaldehyde	11.4	1.7
Acetic acid	9.3	1.1
Formaldehyde	0.3	0.04
Formic acid	0.6	0.06
Total useful products	103.0	15.20

*Measured at 32° F. and 29.9 in. of mercury pressure.

In shipyards, too
COMPETITION FORCES OUR HAND

■ *Everywhere you look in shipyards today, it's weld, weld, weld. Why the sudden, complete change to arc welding?*

ALTER EGO: *Competition!* We were competing with enemy subs and bombers and they *forced* us to build good ships *faster*. We were *forced* to change to arc welding to beat the Axis competition.

Arc welding IS building ships faster, all right—more than twice as fast as the old method . . . just as it's speeding construction of tanks, planes and guns—making them better, too.

ALTER EGO: So look out now for the post-war Battle for Business. Competition will again force change to arc welding to produce better and cheaper autos, home appliances, houses, bridges and other products. We can be forced to change or we can be ready.

Let's put our designs on the alert now with arc welding so we'll get a head start on our competitors.

Ask *your* inner self if competition doesn't force *your* hand.

THE LINCOLN ELECTRIC COMPANY
CLEVELAND, OHIO

Propane

Propane, the third member of the paraffin series, is more easily oxidized than either ethane or methane, also gives rise to a greater number of oxidation products. Thus, it is theoretically possible to produce alcohols, aldehydes, and acids containing one, two, and three-carbon atoms, the one and two-carbon atom derivatives resulting from the fission of the carbon-to-carbon bond. Also, a new type of compound is formed in propane oxidation, namely, acetone, the simplest ketone.

Wiezevich and Frolich[2] reported that by oxidizing 98 per cent propane with pure oxygen at 170 atm. pressure and 660° F., without the use of a catalyst, they were able to convert approximately 5.2 per cent of the feed per pass into oxygenated derivatives. Data presented by these investigators have been recalculated to show the yields of the various products per 1,000 cu. ft. (about 126 lb.) of propane oxidized. These data are shown in Table 2.

TABLE 2—PRODUCTS OF THE PARTIAL OXIDATION OF PROPANE

(Pressures, 170 atm.; temperature, 660° F.; conversion per pass, 5.2 per cent)

	Production/1,000 cu. ft.* (126 lb.) propane consumed	
Product—	Weight (lb.)	Volume (gal.)
Formaldehyde	1.3	0.2
Acetaldehyde	36.7	5.6
Acetone	12.5	1.9
Methanol	40.1	6.0
Ethanol	34.4	5.2
Propanol	29.1	4.3
Butanol	4.8	0.7
Acetic acid (containing formic acid)	11.5	1.3
Total useful products	170.4	25.2
Carbon dioxide	20.7	...
Carbon monoxide	25.4	...
Water	51.6	6.2

*Measured at 32° F. and 29.9 in. of mercury pressure.

These investigators found that the yields of acids could be increased, at the expense of the alcohols and aldehydes, by extracting the acids from the oxidation products and recycling the intermediate oxidation products along with the propane and fresh quantities of oxygen. As might be expected the proportion of propane being oxidized to carbon dioxide and water also increased in this method of operation.

Butane

Oxidation of the butanes (normal and iso), results in the production of a considerable number of oxygenated derivatives. Wiezevich and Frolich[2] report that a sample of 95 per cent butane oxidized readily at temperatures of 410°-490° F. and pressures of 33-160 atm. They were able to identify alcohols containing one, two, three, and four-carbon atoms, acetaldehyde, propionaldehyde, acetone, acetic acid, and propyl acetate. The latter compound is an ester resulting from the reaction between acetic and propanol. These investigators found that in general the lower pressures favored the formation of low molecular weight alcohols and acids, whereas the higher pressures favored the formation of higher molecular weight alcohols and aldehydes.

Bludworth[5] believes that the oxidation of butane can be controlled by a method involving many recyclings of reactants using only very small amounts of oxygen. He indicates that he is able to produce 8 gal. of liquid oxidation products from 1,000 cu. ft. of butane gas by recycling 15 or 16 times. The product was found to consist of approximately 75 per cent methanol, 12.5 per cent acetone, and 12.5 per cent acetaldehyde.

Pentane

The products of the partial oxidation of pentanes are complex mixtures and are not readily separated into individual components. Thus, Wiezevich and Frolich[2] oxidized a mixture of pentanes consisting of 60 per cent normal and 40 per cent isopentane at 465° F. and 200 atm. pressure and obtained a series of alcohols ranging from methanol to the pentanols (containing five carbon atoms) together with acetaldehyde, acetone, and formic and acetic acids. It is interesting that the products were mainly in the two and three-carbon atom range indicating that the pentane molecule was broken between the second and third carbon atoms.

In a small plant operating with a flow rate of 2 g.p.m. it was found that the total liquid oxidation products amounted to 87.5 gal. per day. This plant was operated with recycling of the pentane and a pentane balance indicated that 1.7 gal. of pentane were consumed for each gallon of liquid products. Calculations have been made to show the yields of the various oxidation products for each 100 lb. (19.2 gal.) of pentane consumed and these data are presented in Table 3.

TABLE 3—PRODUCTS OF THE PARTIAL OXIDATION OF PENTANE

(Pressure, 200 atm.; temperature, 465° F.)

	Production/100 lb. (19.2 gal.) pentane consumed	
Product—	Weight (lb.)	Volume (gal.)
Acetaldehyde	5.3	0.8
Methyl acetone*	12.2	1.8
Alcohols (boiling up to 230° F.)†	26.8	4.0
Alcohols (boiling 230°-266° F.)‡	8.7	1.3
Acetic acid	27.0	3.1
Formic acid	2.8	0.3
Total useful products	82.8	11.3

*Mixture of methanol and acetone containing about 15 per cent of the former.

†Believed to contain ethanol, *n*- and isopropanols, and small amounts of *ter*-pentanol.

‡Mainly secondary pentanol with small amounts of *ter*-pentanol.

It was found that the yields of acids could be increased by extracting the acids from the reaction products and recycling the intermediate oxidation products along with the unoxidized pentane. With this method of operation the ratio of production of formic acid to acetic acid was greatly increased. This ratio was about 1 to 11.5 when operating without recycling of the alcohols and aldehydes and when these materials were recycled the ratio was 1 to 2.7.

Hexane

There is little information available in the literature concerning the partial oxidation of hexane. Some work carried out by Wheeler and Blair[7] indicated that the slow oxidation of hexane gives higher aldehydes, unsaturates (mostly ethylene), carbon oxides, and water. Increased temperatures tend to reduce the yields of aldehydes and increase the production of acetic acid. It is believed that the proportions of oxygen in the reacting mixture were higher than would be desirable for the production of high yields of alcohols and aldehydes. The high oxygen concentration may also have accounted for the rather large amounts of unsaturated hydrocarbons present in the reaction products.

Heptane

A mixture of the heptane isomers, obtained from casinghead gasoline, boiling between 158°-207° F. was oxidized by Wiezevich and Frolich.[2] The reaction was carried out at temperatures between 356°-437° F. and at pressures of 135 atm. Under these conditions the heptane fraction would remain in a liquid condition so that this is truly a liquid phase rather than a vapor-phase oxidation. The products were primarily alcohols in the hexyl-heptyl (C_6—C_7) range, but there were produced smaller amounts of the lower alcohols, aldehydes, ketones, and acids.

Mixture of Heptanes, Octanes, and Nonanes

Liquid phase oxidation of a petroleum fraction boiling in the range of 235°-290° F. and consisting primarily of hydrocarbons containing seven, eight, and nine-carbon atoms per molecule, has been found to produce rather high yields of acids.[8] The stock was prepared by extracting straight-run gasoline with liquid sulfur dioxide and fractionating the portion insoluble in the sulfur dioxide (raffinate) to obtain a material of the desired boiling range. This material was found to contain approximately 51 per cent paraffin, 47 per cent naphthene, and 2 per cent aromatic hydrocarbons so that the results obtained in this work are not directly comparable to those obtained with pure paraffin hydrocarbons. It is believed, however, that they might indicate the probable course of the oxidation reaction applied to a similar fraction of natural gasoline, particularly one containing naphthene hydrocarbons.

Briefly, the method of carrying out this type of liquid phase oxidation is to place the fraction to be oxidized in a reaction vessel where it is blown with air at elevated temperatures. The particular fraction referred to above was oxidized at temperatures of 300°-340° F. under pressures of 100 lb. per sq. in. Under these conditions oxidation took place readily without the use of a catalyst.

The main products of reaction were acids although appreciable quantities of alcohols, aldehydes, ketones, and esters were found in the reaction products. Water and carbon dioxide were always formed during the oxidation and resulted from the complete combustion of fragments of hydrocarbon molecules. It was found possible to separate the lower molecular weight fatty acids, in a relatively pure form, from the other products of reaction and the yields of these acids, per 100 lb. (15.9 gal.) of the hydrocarbon fraction oxidized, have been calculated. These yield data are shown in Table 4.

TABLE 4—YIELDS OF LOW-MOLECULAR-WEIGHT FATTY ACIDS PRODUCED BY THE LIQUID PHASE OXIDATION OF C_7 TO C_9 HYDROCARBONS

(Pressure, 7 atm.; temperature, 300°-340° F.)

	Production/100 lb. (15.9 gal.) of charge consumed	
Acid—	Weight (lb.)	Volume (gal.)
Formic	9.0	0.88
Acetic	18.0	2.06
Propionic	4.5	0.54
Butyric	2.0	0.25

A mixture of low-molecular-weight alcohols, aldehydes, ketones, and esters which was readily separated from the oxidation products amounted to over 15 per cent by weight of the hydrocar-

(Continued on Page 266)

Dominican Oil Law Contains Features to Encourage Capital

THE petroleum law enacted recently by the Dominican Republic is unique in its selection of the best features of similar legislation in other oil producing countries, as well as its avoidance of provisions which discourage the investment of capital necessary to develop and maintain production.

The principal features of the Dominican law are these:

1. A concession for exploration and exploitation granting 3 years to explore a lot selected in free land by a concessionaire, which may have a maximum area of 10,000 ha., or some 24,711 acres. More than one lot may be obtained by one company. An initial tax of two centavos, or 2 cents in United States currency, per hectare is charged for this concession, plus 50 pesos ($50) in stamps on the concession document.

2. At the end of the 3-year exploration period the concessionaire has 6 months to select up to half the area of his lot, in parcels not exceeding 500 ha., for exploitation over the next 40 years. The remainder of the area becomes a national reserve. The concessionaire pays 50 centavos for the certificate issued for each parcel, plus an initial exploitation tax of 10 centavos per hectare on the parcel area, plus 5 centavos per hectare annually for 3 years. The annual rate then rises to 10 centavos for the next 27 years and to 15 centavos during the final 10 years of the agreement.

3. If oil is discovered, the government is paid, in addition to the above, a royalty of 7 per cent of its value during the first 2 years, 9 per cent during the next 5 years and 10 per cent for the remaining 33 years of the agreement. The value of this participation must never be lower than 40 centavos per ton, and the government has the option of taking its share in oil instead of cash.

4. The taxes to be paid by the concessionaire are set forth clearly in the petroleum law and he pays no others except those of a general nature. He is specifically exempt from export duties on oil production and from import duties on machinery, implements and other equipment used in connection with the working of his concession. Nor does he have to pay license or income taxes, or levies by municipalities.

5. The concessionaire may freely dispose of his oil, refine it and transport it. His exploration and exploitation concession includes generally the privileges of refining and transportation which are granted by specific concessions to those engaged only in such activities.

6. The law also provides for initial exploitation concessions, for concessions on lands under water, for national reserves and their exploitation, as well as for coal mining. Government ownership of the subsoil is firmly established in the law but provision is made for recognition of concessions granted prior to enactment of the present legislation and for their adaptation to its terms.

The only oil operations at present in the Dominican Republic are the exploratory activities of the Dominican Seaboard Oil Co. This company has one standard rig which will be used to drill a test on the Comendador structure in the western part of the Benefactor Province. The location is only a few miles east of the Haitian border.

Dominican Seaboard has carried on considerable geological work in the country. Much of the work has been done by aerial photography which has aided in working out surface geology. This work has been concentrated in the so-called intermountain basin areas. Actual drilling activity has been delayed by the inability of the company to transport equipment from the United States. This includes some of the auxiliary equipment for the rig already there and a small, semiportable diesel rig which has been awaiting shipment for some time.

Oil was discovered in Santo Domingo about 1904 as the result of seepages on what is now known as the Higuerito structure almost directly north of the city of Azua on the Bay of Ocoa. In 1939 the Maleno structure, a few miles west of Higuerito, was discovered and two producing wells were drilled there. The initial production of these wells was several hundred barrels per day from around 450 ft.

●

DEATHS

WILLIAM J. HINCHEY, 62, general manager of Kentucky Natural Gas Corp., Owensboro, Ky., died last week at his home. He had apparently been in excellent health, and the heart attack which proved fatal was very sudden. A native of Bradford, Pa., Mr. Hinchey left there 25 years ago. He had recently completed his forty-third year in the natural-gas industry. He is survived by his widow.

CHARLES A. McLOUTH, 89, retired pipe-line official, died at an Oil City, Pa., hospital last week. He had been in ill health for several months. Mr. McLouth had been engaged in the pipe-line business for nearly 50 years prior to his retirement from the Southern group about 20 years ago. Two daughters survive.

RICHARD O. RIDDELL, 47, Denver, Colo., regional chief accountant for Texas Co., died from a heart attack last week while on a train en route from Denver to Topeka, Kans.

CLODIE EDMOND PAXTON, 43, died last week at Tulsa, following a paralytic stroke. Mr. Paxton, a welder for Oklahoma Natural Gas Co., came to Tulsa 6 years ago from Flag, Ark. His widow survives.

DAVID W. HAERING, 34, head of D. W. Haering Co., Chicago, a water-corrosion authority, died last week in a Chicago hospital. He was born in Chicago and educated at University of Illinois. His widow survives.

T. L. FOSTER, general attorney for Sun Oil Co., died at his home in Dallas, Tex., last Saturday. He had lived in Dallas since 1925. His widow and a daughter survive.

J. A. TODD, 50, of Magnolia, Ark., field superintendent of Carter Oil Co., died suddenly at his home November 7. He had worked all day the day before and had not complained until a few minutes before his death.

PROF. STANISLAS PILAT, prolific writer on the chemistry of naphthenic acids and their derivatives, died at enemy hands in Lvow, Poland. He had been a member of the Institute of Petroleum for 16 years. His last publication, "Properties of Synthetic Lubricating Oils," appeared in the Institute's journal just a year ago. His widow survives.

DR. LEOPOLD SINGER, 73, a native of Vienna, died during the summer in London. He had long been on the foreign staff of Universal Oil Products Co., Chicago. He started his practical career at his father's refinery at Orsava, and began to replace the empirical methods of the time with more scientific methods. He held numerous patents, especially on fractionating columns, high-vacuum distillation plants, and lubricating-oil and paraffin-wax production.

WILLIAM M. ADAMS, 79, pioneer Glenpool, Okla., oil man and farmer, died last week. He came to Oklahoma 47 years ago, driving a covered wagon into Indian Territory. Mr. Adams had been ill for 2 years from heart disease. His widow, two daughters and a son survive.

JOHN J. FITZGERALD, 59, of Hope Construction & Refining Co., died at Pittsburgh, Pa., last week. A native of Ohio, Mr. Fitzgerald formerly was associated with the late Col. J. J. Carter, eastern oil operator, and founder of Carter Oil Co. in West Virginia. His widow and two children survive.

WILLIAM WOODLEY, 84, at one time prominent among Canadian drillers in Rumania, Sumatra, Australia and other foreign fields, died recently at London, Ont., Canada.

ELIAS J. BAUM, 55, for 25 years a consulting engineer with Shell Pipe Line Co., died Friday in a Houston, Tex., hospital. His widow survives.

●

Changes Made in Procedure To Obtain Price Adjustment

WASHINGTON, D. C.—Two new amendments just issued by Office of Price Administration to existing price orders provide for changes in procedure of application for adjustment and also set terminal dates for such application. They apply, first, to products sold at retail, and second, to "petroleum and petroleum products" under Price Schedule 88.

Under Amendment 11 to Maximum Price Regulation 137, applications for adjustment or revision of maximum prices will be made under Revised Procedural Regulation 1, whereas before these applications have been made in accordance with Procedural Regulation 2. Information as to the new application form must be obtained from OPA. The amendment also fixes November 30, 1942, as the last date under which an application for a price adjustment in products sold at retail may be received.

Amendment 39 to Price Schedule 88 sets November 15 as the last date on which applications for an adjustment on prices of petroleum and petroleum products will be entertained, and at the same time, provides that Revised Procedural Regulation 1 shall be used.

Gasoline Rationing Date Postponed to December 1

WASHINGTON, D. C.—Postponement of gasoline rationing for the present nonrationed areas of the country from November 22 to December 1 was announced here Tuesday. Date of registration for rationing in turn is being postponed from November. In turn, the date of registration, originally scheduled for November 9, 10, and 11, has been delayed until November 18, 19, and 20.

Inability to obtain the necessary forms and the "A" ration books was given as the reason for the postponement. The delay in obtaining ration books and other material is practically nation-wide, it was stated, and accordingly the postponement was made nationally in the interest of uniformity.

Start of rationing under "T" books for trucks, taxis, and other commercial vehicles in the East, as well as in the Middle and Far West is in the same status as the rationing of gasoline for passenger cars.

Natural Gas News

Tennessee Company Seeks Authorization to Construct 24-in. Natural-Gas Line

WASHINGTON, D. C. — The Federal Power Commission last week announced its order setting hearing at 9:45 a.m., December 8, on an application by the Tennessee Gas & Transmission Co., Chattanooga, Ten., for a certificate of public convenience and necessity to construct and operate a natural-gas pipe line from southwestern Louisiana gas fields to Nashville, Chattanooga, Knoxville, and other Tennessee communities. The applicant also proposes to deliver gas through the facilities to existing pipe-line companies for transmission into Ohio and Pennsylvania to relieve a threatened gas shortage in the Appalachian area.

Commission officials said that hearing on the application, which was filed last February, is desirable at this time to settle questions of public convenience and necessity so that construction could be hastened if preference ratings for required materials are issued by the War Production Board.

The proposed pipe-line system will consist, according to the application, of gathering lines to transport natural gas to a point of convergence near Eunice, La.; a main line, 24 in. in diameter, to transport the gas through the states of Louisiana and Mississippi to a point near Muscle Shoals, Ala., and thence to Brace, Lawrence County, Tennessee. From Brace, two main lines will diverge, one of which, either 16 or 24-in. diameter, will transport gas to a point near Nashville, Tenn., and the other, 12¾-in. diameter, will carry gas to a point near Alcoa and Knoxville, Tenn. The construction of lateral lines to reach aluminum and chemical plants in Tennessee, certain plants of the Tennessee Valley Authority in Alabama and Tennessee, and the cities of Nashville, Knoxville, and Chattanooga, Tenn., is also contemplated. Construction of numerous lateral lines originally proposed to be built to serve many other communities and industries in the Tennessee Valley and western North Carolina must necessarily be postponed until after the war emergency, according to the application.

The proposed system is represented to have a delivery capacity, without any compression, of 155,000,000 cu. ft. per day. With one 5,000-hp. compressor station located 282 miles from the beginning of the main line, the capacity of the line can be increased to 204,000,000 cu. ft. per day, the applicant says. With compressors at intervals of 94 miles, the available capacity at Brace, Tenn., can be increased to approximately 300,000,000 cu. ft. per day, it is claimed.

It is also stated that the proposed line, in addition to rendering full service to the Tennessee Valley area, could make 100,000,000 cu. ft. of gas per day available to the Appalachian area with a single compressor station, and that with full compression not less thn 200,000,000 cu. ft. could be delivered daily to companies in the critical area.

The application contends that since the gas supply for the proposed system will originate in the "distillate fields" of southwestern Louisiana, and since the heavier hydrocarbons necessarily produced with such gas will have to be removed from it prior to delivery to applicant's pipe line, the consummation of the project would immediately afford to the war program a new supply of motor and aviation fuel amounting to from 72,000,000 to 108,000,000 gal. annually, based on a recovery ratio of about 1,000 gal. of natural gasoline per 1,000,000 cu. ft. of natural gas.

•

Plea Denied for Rehearing On Panhandle Eastern Rates

WASHINGTON, D. C.—The Federal Power Commission last week denied petitions filed on October 23 by Panhande Eastern Pipe Line Co. and its affiliates, Michigan Gas Transmission Corp. and Illinois Natural Gas Co., all having main offices in Kansas City, Mo., for a rehearing and for stay of the commission's September 23 order reducing the companies' wholesale rates and charges for natural gas by not less than $5,094,384 annually. The commission's order and Opinion 80, issued September 23, directed that an interim rate reduction be made in the companies' rates and charges for the sale of natural gas in interstate commerce for resale for ultimate public consumption.

The commission based its refusal for a rehearing on the ground that "no new facts have been presented or alleged in the respondents-defendants' petitions which would justify a reversal or revision of the commission's order and opinion, and no principles of law are stated in said petitions which were not fully considered by the commission before it entered said order and opinion."

Earlier the commission had announced an order extending from October 15 to November 10 the time within which Panhandle and its affiliates must file new schedules of rates and charges to reflect the required reduction. The order provided, however, that the reduced rates must be effective as to all bills regularly rendered on or after November 1, as originally ordered by the commission.

The Panhandle system constitutes the longest natural-gas pipe line in the world and serves more than 200 cities, towns, and communities with more than 700,000 retail customers in Texas, Kansas, Missouri, Illinois, Indiana, Michigan, and Ohio.

El Paso Natural Gas Co. Is Ordered to Reduce Rates

WASHINGTON, D. C.—El Paso Natural Gas Co. and its wholly owned subsidiaries, Western Gas Co. and El Paso Gas Transportation Corp. last week were ordered to reduce wholesale natural-gas rates by not less than $526,000 per year, it was announced today by John W. Scott, federal power commissioner in charge of the investigation. The reduction ordered is based on 1941 sales to distributing companies. It is expected that for the next 12 months the reduction will be in excess of $700,000 due to increased sales of natural gas.

The reduction ordered marks the culmination of the commission's investigation of the interstate wholesale rates and charges of El Paso Natural Gas Co. and its affiliates instituted upon complaint filed by Gov. Sidney P. Osborn of Arizona on March 4, 1942.

Hearings commenced on September 30, 1942, in Phoenix, Ariz., and the commission's staff concluded presentation of its evidence in El Paso, Tex., on October 24.

The commission's order states that existing rates of the companies are unjust, unreasonable and excessive to the extent of at least $526,002 annually on the basis of the wholesale gas sales for 1941.

The order makes effective new uniform city gate rates for gas delivered and sold on and after November 1, 1942, in each of the three states affected. In Arizona the present average rate for domestic and commercial gas is reduced from 30.92 to 22 cents per 1,000 cu. ft., and industrial from 23.35 to 18 cents. In Texas the domestic and commercial rate is reduced from 27.23 cents to 19 cents, and the industrial from 19.61 to 16.5 cents. In New Mexico, domestic and commercial gas is reduced from 35.28 to 21 cents, and industrial from 25.69 to 18 cents.

The commission found a rate base for the entire El Paso Natural Gas Co. system of $21,374,069, representing original cost in the amount of $25,538,341, less accrued depreciation of $4,576,470, plus $412,198 for working capital. These figures reflect the elimination by the commission of $1,800,460 from plant accounts, including a write-up of $925,000, excessive amounts paid for lands of $269,112, organization expenses of predecessor companies and unsupported charges to organization of $130,410, abandoned plant of $153,026, unsupported and improper charges for gas sales contracts of $203,718, and operating expenses erroneously charged to plant account of $119,194.

A rate of return of 6.5 per cent per year was used in arriving at the reduced interstate wholesale rates. The commission found that operating revenue from the sales subject to its jurisdiction in 1941 was $1,928,609, which amount exceeds by $526,002 the allowable operating revenue deductions and expenses of $1,402,607.

Request for Gas-Rate Boost At Louisville Is Withdrawn

WASHINGTON, D. C.—Upon request of the United Fuel Gas Co., Charleston, W. Va., withdrawal of a proposed schedule calling for an increase in rates for natural gas sold to the Louisville Gas & Electric Co., Louisville, Ky., has been authorized by the Federal Power Commission. A hearing on the proposed increase which was to have been held in Washington November 9 was cancelled.

•

Natural Gasoline

Canadian Gasoline Sales Slump

OTTAWA, Ont.—Rationing of gasoline in Canada has resulted in a substantial reduction in motor-fuel sales. During July, the last month officially reported, sales for all Canada totaled 88,149,000 gal., compared with 110,014,000 gal. for the same month last year, a decline of about 19 per cent. For the 7 months of 1942 sales were 495,065,000 gal., against 538,170,000 gal. in the same period of 1941.

A.P.I. SECTION

M-68 Will Result in Drilling of 13,000 Fewer Wells in 1942

By DON R. KNOWLTON
OPC Director of Production

A. P. I.

Improved production methods such as pressure maintenance and repressuring were suggested by Mr. Knowlton as worthy of the industry's consideration in offsetting the failure or inability to discover substantial new reserves by exploratory drilling.

In this paper, presented at the November 12 meeting of the A.P.I. Production Division, Mr. Knowlton warned the industry that it would be called upon for an even deeper cut in the use of materials during 1943, probably reducing completions to around 50 per cent of the number recorded in 1941 compared to a cut of 40 per cent this year.

Mr. Knowlton, before joining the Office of Petroleum Coordinator as director of the Production Division, in January 1942, was manager of production of Phillips Petroleum Co., Bartlesville, Okla.

THERE are two or three things which I would like to take this opportunity to discuss. First, I would like to review the 11 months' history of Conservation Order M-68. You will recall that in the early fall of 1941 we in the petroleum industry were given to understand that those engaged in the production of petroleum would have to reduce our steel consumption during the year of 1942 at least 40 per cent below the 1941 consumption. It was proper that the Office of Petroleum Coordinator should be the agency charged with the responsibility of rationing the 60 per cent of the steel to be made available. There were three ways in which it could be done. Some felt that the available steel should be directly allocated, joint by joint and valve by valve, to those wells and other uses which OPC and the War Production Board deemed entitled to the material. Others suggested that spacing rules for every field in the country should be written. The view of the Office of Petroleum Coordinator, and the view which finally prevailed, was to establish a country-wide rule governing the use of materials with a provision for exception where it was shown to be appropriate that an exception be granted. Conservation Order M-68 was the result.

You will remember how slow we were in disposing of the early applications for exception. Several of us joined the OPC staff about the time the order was issued and had to be indoctrinated with a new way of doing business. Applications for exception to the order were pouring in faster than we could handle them. Some of the cases were extremely difficult to judge and about that time I began to understand and appreciate the trials and tribulations of our friends, the regulatory authorities, who sit in judgment on the various petitions of the industry. We did, however, get started finally and after several weeks we managed to handle the cases on a current basis. Since then we have handled the cases currently, but I have discarded the hope expressed at the Dallas meeting of the A.P.I. that a 1-week service could be inaugurated. Ten days to 2 weeks seems to be our lower limit.

Since the order was first promulgated we have handled over 3,000 applications. Some have been for one well only, some have been for as many as 60 wells, and other applications have covered the installation of pumping equipment or the changing of production facilities on one or more wells. Of the applications filed shortly after the promulgation of the order approximately 50 per cent were denied. As the principles which governed the office in passing on the applications for exceptions were evolved and became known to the industry the percentage of the applications which were approved increased. Presently there are fewer applications being filed and of these which are filed approximately 90 per cent are being approved. When the year is done the year's use of steel will be within 1 per cent of the quota set—60 per cent of that used during 1941.

Splendid Cooperation

The manner in which the producers of the country react to Conservation Order M-68 is, in my opinion, a splendid testimonial to the way the oil industry cooperates any time a sacrifice is needed to get a job done. The patience and understanding, and the help tendered by all elements of the industry, major companies and small independents alike, were extremely gratifying to us at a time when we needed all the help available. I want to thank you for your patience.

As a result of M-68 the industry will, in 1942, drill 13,000 fewer wells than would have normally been drilled. The steel which would have been consumed in equipping these wells is sufficient to build 26,000 fighting tanks. This quantity of steel will build half a million—half a million—of the 2-ton "block buster" bombs which are so tormenting to the unholy triumvirate these days. If you ever get to wondering what your contribution to the war program has been, think of these figures—26,000 tanks—half a million "block busters."

This coming year you will be called on for an even deeper cut in your use of materials. Our analysis indicates, however, that if we are to carry out those production operations which we

C. F. KELLY, Humble Oil & Refining Co. | L. P. EVANS, Socony-Vacuum Oil Co., Inc. | L. C. BEARD, JR., Socony-Vacuum Oil Co., Inc. | A. F. FORZIATI, National Bureau of Standards | C. HAROLD HERR, Pennsylvania State College

deem to be essential in order to safeguard our oil supply, our opinion is that the cut should not exceed 20 per cent under this year's consumption. This will bring us down to about 50 per cent of normal. The War Production Board will have the tremendous responsibility of distributing the available steel to the war plants and essential industries. In our dealings with the War Production Board we are spreading every card on the table—face up. There has been no attempt to exaggerate our needs. Plain facts, in plain words, has been our theme.

Selective Drilling Sure to Come

Selective drilling is bound to come. And when it does, you will find drilling in some areas spread out to one well to 160 acres—maybe more—just enough drilling to define field limits and let us know how much oil we can plan on recovering. Materials are just that scarce.

In anticipation of the time when it may become necessary to scrape the "bottom of the bin," we have recently asked the industry, through its district production committees, to undertaken a nation-wide survey of its production facilities to determine what quantities of materials may be reclaimed from those facilities and devoted to other uses, preferably without jeopardizing ultimate recovery of reserves.

In a manner of speaking, we are asking the petroleum industry to do with its productive facilities what the Selective Service System has done with the manpower of the nation. The 1-A wells and production facilities—those from which material can be made readily available—will include presently idle wells, high water-oil ratio wells, high gas-oil ratio wells, closely spaced wells, and other production facilities that may be dispensed with without injuring ultimate recovery. Wells in the 1-B classification will include those border-line cases—wells that are presently being produced profitably but which may be looked to as a source of materials and equipment if the materials shortage continues to be critical and the war is prolonged. Obviously, in such a classification, we reach a type of well that is the backbone of the nation's oil production. It is that type of well for which we will need repair and maintenance materials, in order that its productive capacity may be unimpaired. The weaker, unnecessary wells must be looked to as a source of materials with which to drill and maintain better wells, capable of contributing more to the war program.

There is one other thing: we hear so much about the need for exploratory drilling that I wonder if improved production methods such as pressure maintenance and gas and water repressuring are receiving the attention they merit. A temporary subcommittee on secondary recovery for Oklahoma has compiled a report showing that half a billion additional barrels of oil are available in that state through secondary recovery. It takes a lot of wildcat drilling to uncover a reserve of that quantity.

It is going to be absolutely essential that in every case where it is possible to substitute an advanced operating practice for the use of material that such a practice be instituted. The industry has always taken the lead in developing improvements and I am confident that it will continue to do so. I want to assure you, however, that if we can be helpful in any way at all, we want you to call on us.

War Causes Dislocations in Natural-Gas Industry

By E. HOLLEY POE
OPC Director of Natural Gas and Natural Gasoline Division

THE problems of the natural gas and natural-gasoline industries are in large measure the same problems that are faced in the production, transportation, refining, distribution, and utilization of oil and its many byproducts. As regards natural gas, it differs from oil only in that it is a well-to-burner operation. Therefore, reserves to balance supply with demand must be developed and kept in formation in readiness for a rush call to meet high peak demands. With the exception of a few places where underground storage is maintained there is no major means of storing natural gas close to the great critical industrial centers in the nation today.

The problems resulting from the impact of war include:

1. Increased demands by both war industries and private industries as well as the normal increase of about 12 per cent in civilian usage.

2. Lack of materials to expand facilities in keeping with these increasing demands.

3. Increasing shortage of manpower brought about by enlistments, induction into the armed forces and migration of workers to other war industries.

4. Increased expenses resulting from the rising cost of labor, materials, and operating supplies.

5. The heavy tax burden, present and prospective, in the view of expenditure of tremendous sums of money in order to supply demands of the war effort.

6. Ascertaining the expected requirements of natural gas, natural gasoline and related hydrocarbons by all phases of the war effort in time to provide for them.

7. The need for relief during the war period from express or implied covenants contained in leases by reason of limited supplies of critical materials which prevent the orderly drilling of wells on such leases.

The prediction is made in this paper major natural-gas pipeline construction will be required in OPC District 2 within the next 18 months if adequate supplies are to be maintained.

Mr. Poe, formerly secretary of the Natural Gas Section, American Gas Association, reviewed the outlook for demand and supply of natural gas before the November 12 group meeting, A.P.I. Division of Production.

Modifications of M-68 in other districts may be necessary in order to meet the increased demand which in the domestic field alone amounts to 12 per cent this year.

Appalachian Region Reserves

The Appalachian region contains about 6 per cent of the proved natural-gas reserves of the nation, and the market served equals 18 per cent of the natural-gas sales. Order M-68 was relaxed as respects the drilling of gas wells in this area. As a result of the recent drilling program in this region, it appears that there will be only a few areas within the region where actual shortages will appear on peak-load days during the coming winter. With the drilling of fewer wells there has been developed a greater deliverability than during the previous year. In the very near future, however, if the war markets in this region are to be adequately served by natural gas, thus free-

AUTHORS AND CHAIRMEN OF COMMITTEES AND TECHNICAL GROUPS

W. S. CRAKE
Shell Oil Co., Inc.

PRESTON E. CHANEY
Sun Oil Co.

W. A. ALEXANDER
Shell Oil Co., Inc.

H. S. MOSS
H. S. Moss Petroleum Co.

ing oil for other uses, there is no doubt that there will be need for increased transportation facilities from the great reserves of the Southwest.

In District 2, gas to supply large and important markets is transported through long trunk-line systems originating in the reserve areas of the Texas Panhandle, Oklahoma Panhandle and southwestern Kansas, or in the fields of Louisiana and Texas. Ability to supply the demand is limited only by the deliverability of existing pipe-line systems.

As respects other markets not attached to these trunk-line systems, the greater part of the gas produced and marketed is being produced from old fields that are now nearing depletion and from which gas is being taken during peak load at peak deliverability.

The Michigan gas supply is largely an intrastate situation, and while they have adequate supplies at the present time, their reserves are relatively small when compared with the markets served.

Illinois has practically no marketable gas. Oklahoma is producing almost entirely from highly depleted pools. There are some new pools such as the Cement area and the deeper sands in the Chickasha area, but the demands on these fields indicate that their depletion will be rather rapid. The old pools of Kansas appear to be from 50 to 80 per cent depleted. In this area and in western Missouri and northeastern Oklahoma, the provisions of M-68 were relaxed to allow as great a development as possible to take care of the current winter's requirements.

Need Pipe-Line Construction

There will be peak-day curtailment in many parts of this district and the shortage of fuel oil for standby service is becoming acute. Indications are that in this district, within the next 18 months, there will have to be some major pipe-line construction if adequate supplies are to be maintained. In the meantime we are encouraging the exploration of new areas within a reasonable distance of main transmission lines where such lines will be able to transport additional gas to meet the peak loads.

The prospects for new discoveries of any new major gas reserves in this area do not, at this time, appear very encouraging. By reason of this over-all condition in District 2, we have had to deal with a situation prevailing in the Hugoton field in western Kansas and the Panhandle of Oklahoma. As you all know, this field constitutes about the largest single unified gas reserve in the world, and relatively little gas has been withdrawn from it to date. The occurrence of gas in this field is so uniform and regular that a producing well is almost certain to be encountered in any location in the field. Something over 300 wells have been drilled and there are about 28 to 30 wells that have been drilled but are not at this time connected to market outlets. The potential gas available from the wells already drilled is more than sufficient to supply the demands of all the pipe lines dependent upon the field for their supply. Notwithstanding this, drilling operations continued in the field. The recent supplement to Conservation Order M-68 has curtailed all further drilling operations in this field without the approval of the Office of Petroleum Coordinator for War.

It is the consensus that in order to conserve critical materials as well as the gas reserves of the field, a proper proration program must be put into effect. The Natural Gas and Natural Gasoline Division has sponsored joint action by the state regulatory commissions of Oklahoma and Kansas, looking toward a solution to this problem.

As far as practicable, in encouraging such orders, we recognize that any attempted proration should be predicated on the most direct and least complicated approach, giving reasonable recognition to the correlative rights of the owners of reserves in place and least interference to the withdrawal of gas in withdrawal of gas in keeping with varying seasonal needs.

South of Lat. 39, west of the Mississippi River, north of the Gulf of Mexico and the Rio Grande lies the nation's greatest fuel reserve. In the case of natural-gas reserves it contains the equivalent of something over 70 per cent of the total. In the case of production of natural gasoline and related hydrocarbons the percentage would be greater. It is one of the most important training areas for our armed forces in the country. It is likewise an area in which there is tremendous war-industry activity. It is the region to which we must all look for the greatest source of supply of oil, natural gas and natural gasoline and related hydrocarbons because new discoveries of production in this area are generally more prolific than in other areas of the nation. It is the area in which the greatest encouragement for new exploration and development should prevail.

In this area there are large reserves of distillate and large concentrated gasoline-plant capacity producing the largest available supply of natural gasoline and related hydrocarbons which are so critical to the war needs.

The plants of this industry perform a great service in normal times in conserving what would largely be waste products of great value, and in this war period this service can become vital as they make up the deficiency of hydrocarbons at the plants of those refiners who are turning out necessary war materials.

District 4, comprising the Rocky Mountain states, is the least densely populated of any of the districts. It supports many industries vital to the war program. Large volumes of natural gas are used in the smelting and refining of nonferrous metals, the production and refining of oil and the refining of beet sugar. Many new military establishments are also dependent upon gas for fuel. Except for gas from the Panhandle field of Texas, transported for utilization in Colorado, the area is largely selfsustaining from the standpoint of natural gas supply.

District 5 Has Unique Position

District 5, the Pacific coastal area, being separated as it is from the remainder of the country by the Rocky Mountains, is entirely dependent on gas produced within the immediate environs. California, the only large producer of natural gas in the district, has the largest number of gas consumers of any state and is the only large producer of natural gas that does not export or import any of this natural fuel. Because California's natural-gas production is predominantly casinghead gas, increased demands and scarcity of critical materials have resulted in unusual problems.

In order to conserve gas produced in association with oil in excess of summer demands and utilize it to meet peak demands during winter months, there was needed an adequate storage. As a result of cooperative study of the California Railroad Commission, local oil and gas operators, and the Office of Petroleum Coordinator, it was determined that the partially depleted Playa del Rey oil pool had characteristics suitable to use for gas storage.

Upon recommendation of the Office of Petroleum Coordinator, the Playa del Rey reservoir, near the center of the gas-distribution system of the Los Angeles Basin area, has been taken over by the Defense Plant Corp. and will be operated as a gas-storage reservoir to be used primarily as a source of supply to meet emergency peak-load conditions. Geological studies of the structure indicate that the capacity of the field will be approximately 3 billion cubic feet. Of this, 1 billion cubic feet will be allowed to remain in the formation as a pressure backlog and 2 billion cubic feet will be available for current storage. Three miles of 12-in. pipe has been laid from the Southern California Gas Co.'s 26-in. main line. This line has already been connected to the injection wells and gas is being injected in small amounts at line pressure of approximately 160 lb. pending the installation of a compressor plant.

Major Developments in 1942

Among the major developments of District 5 during the past year are:

1. The conversion of the Stanpac line from a gas line to an oil pipe line and the subsequent rearrangement and addition of natural-gas facilities to handle additional gas from the Rio Vista gas field to the San Francisco area.

2. The general increase in crude-oil production and particularly the shifting to more low-gravity crude at low gas-oil ratios to get greater fuel-oil yields. This program necessitated some changes in gasoline-plant facilities and gas-handling facilities.

3. The increased demand for isobutane was met by full cooperation of gasoline-plant operators in increasing their plant efficiencies and providing facilities for maximum recovery of isobutane. Our last report indicates about 97 per cent of isobutane is being delivered to manufacturers of 100 octane.

4. To conserve all gas production, a gas-conservation committee under the direction of the production committee and assisted by the natural-gas and natural-gasoline committee, has produced most excellent results. The investigation made every operator conscious of the problem, and by voluntary cooperation, practically all of the existing situations have been or will shortly be corrected.

5. Through the cooperation of the production committee, with the Natural Gas and Natural Gasoline Division, the production of natural gas is being regulated to meet the gas demands. The fact that only two fuels are generally available in California; namely, fuel oil and natural gas, presents an immediate problem due to the need for accumulating maximum stocks of fuel oil for war purposes. This requires that the maximum fuel need of industry in the district be met with natural gas and requires the maximum production of casinghead gas to meet the requirements in southern California.

Conservation is the biggest word in the supply phase of the war effort. Likewise, when we talk about the conservation of oil and gas we are talking about the life span of the oil and gas industry. When we deal with it we are dealing with the industrial future of the nation and with the health, comfort and future of our citizens.

Conservation of natural-gas reserves and conservation in the production, transmission, and utilization of natural gas must be faced positively by all of us. Sound policies must be encouraged and sound laws and their proper enforcement be sincerely advocated. The importance of proper utilization of gas produced with oil calls for continued support of studies designed to permit the proper use, in an orderly manner, of the gas produced with oil, which heretofore has been blown in the air and wasted.

The war emergency will cause many dislocations in our operations, but on the credit side dire necessity will teach us much about better production methods, better transportation and distribution methods, better ways and means not only of conserving the product but of preventing the economic dissipation of it.

The Army's Internal Security Program

By H. G. REYNOLDS
Colonel, Provost Marshall General's Office,
Washington, D. C.

THE internal-security program of the Army is designed to provide the most complete protection possible for facilities, installations, utilities, and materials in the continental United States against sabotage and internal threats, in order to safeguard the continuous flow of production of essential materials to the armed forces.

Plant Protection Division

In November 1940 the Plant Protection Division was formed in the office of the undersecretary of war. That office was charged with the supervision of activities in connection with production, and it was felt that the protection of production was so important that special plans for safeguarding it should be made. We started first with what are known as the supply services, and we established a system of inspection forces in each procurement district of the supply services. For example, the Ordnance Department has inspection forces in Boston, New York, Philadelphia, Rochester, Detroit, Chicago, and other important places where contracts were made for ordnance material. The Signal Corps, Engineers, Quartermaster, and other supply services established the same inspection offices. All these activities were supervised and coordinated by the Plant Protection Division in the office of the undersecretary of war. The Army Air Forces were organized in a similar manner and, as you know, their program included vital plants of your industry which are producing aviation gasoline and other petroleum products. The other services were, of course, represented but, in general, the oil industry's interests are more important to the Air Force, Quartermaster, and the Ordnance Department than any of the others.

Consolidation of Services

Early in 1942 it was felt that we should decentralize some plant-protection activities to cover specific industries, and we assigned Maj. Frank E. Wilder, who is well known to many of you, to that duty. He started early in March, and it is my belief that he has accomplished a great deal not only in bringing your organization closer to the Army, but in impressing upon the industry the great importance of proper protection. About that same time it was decided that the Plant Protection Division, office of the undersecretary of war, should be merged with the Emergency Operations Division in the Provost Marshall General's Office. The Emergency Operations Division supervised all activities in connection with the use of local and state police, state guards, and of federal forces if required, and the supervision of certain emergency plans formulated by the War Department. This was done in order to attain an over-all internal-security program which would include not only protection within the fence line of a plant, but also would extend to areas contiguous to the plants and to all suppliers of raw materials and the carriers.

A further development was the transfer during this past summer of internal-security functions from the procurement districts of the supply services to the commanding generals of the service commands. There are nine of these service commands, and this transfer obviated certain duplication of inspection, and centralized the control of inspection forces so that vital plants, facilities, installations, and materials could be protected through the commanding general of the service command in which the plants were located. For example, an inspector from the Second Service Command visits an oil refinery in New Jersey. He makes recommendations for the improvement of its protective installations through recommendations to the management. His report is correlated with the reports of other inspectors in offices who are concerned with the surrounding territory, the railroads, sources of raw material, and the available military and naval forces. In this manner we attempt to provide over-all internal security for a vital plant of this type.

The primary responsibility for internal security rests with the owner, operator, or management. Local police and county and state officials are secondarily responsible; and, finally, if in the opinion of the commanding general of a service command military assistance is required, it will be provided from the forces under his command.

Fire Protection

We originally established eight so-called "standards of plant protection." These have remained in force throughout the 2 years that we have been working. War has changed some of the minor requirements, but in general the basic principles remain unchanged. First, we consider fire to be the most dangerous enemy. The saboteur can start a fire and leave no trace. A fire completely destroys productive power, and with the shortage of replacement materials it is virtually impossible to replace an important plant that has been destroyed.

Personnel

Almost as important as fire is the control over personnel. If you know who is working for you as a result of a comprehensive and thorough examination of the background of a prospective employe, you have won a large part of the battle against the potential saboteur. We stress the importance of competent personnel offices and complete records and investigations in all of our recommendations to management. Another very important phase of the personnel problem is employe education. Unquestionably the great bulk of your employes are loyal Americans. If you can mobilize and direct this loyalty, you can create a very potent protective factor. This protective factor can be secured, however, only by a continuous and effective employe educational program.

Accident Prevention

Next, we are concerned with accident prevention. This is a development which has expanded in recent months. Man power is becoming so short that we must conserve all that we have in every possible way. The greatest destroyer of man power is an avoidable accident. We are, therefore, putting particular emphasis on the necessity for taking every precaution to wipe out any condition which might endanger the ability of any employe to work productively.

Visitors

Control of visitors is important. Not only do visitors waste the time of management, but there is always the chance that a visitor may be someone who is seeking information to which he is not entitled. We attempt, therefore, to keep visits to a minimum. It is a most difficult problem, because some visitors are production men, service men, or subcontractors who are necessary for the furtherance of productive activity. Others are municipal, state, and federal inspectors who are permitted by law to enter plants. This latter group is permitted to carry on its functions, but we attempt to keep the number who are granted permits to a minimum. The third type of visitor is the most difficult to handle. These are public-relations men who can sometimes render a great service, or they are mere sightseers whom we must keep out even though it causes great irritation to them and their sponsors who are frequently men in high positions.

Employe Identification

The identification of employes is another standard of plant protection. Employes should not be permitted to enter areas except those in which they are working. Employes must be identified when they enter and leave the plant, and spot checks should be made frequently of packages or food containers carried by workers and of their automobiles. This control also extends to the supervision of trucks and railroad cars. There is an excellent chance for the saboteur to enter a plant as the employe of a carrier, and we urge strict company regulations for the control of these activities.

Confidential Information

The care and safeguarding of confidential plans and documents is, of course, important. Carelessness in this regard is much more common than you may imagine. We recommend great care in the safeguarding of information which might be of value to the enemy.

(Continued on Page 264)

A.P.I.

In this article the author explains how the Army goes about providing for protection of productive capacity of the nation against sabotage and internal threats. Col. Reynolds, a native of Massachusetts, served on the Mexican border with the Eighth Massachusetts Infantry. He was commissioned a second lieutenant in the Regular Army, and served overseas. He resigned his commission in 1919 to enter commercial business, and was called back into service in November 1940.

Paper presented at the Group Session on Protection of Petroleum Facilities at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

Deliver 1,400,000 Bbl. Daily to East Coast, OPC Goal

By J. R. PARTEN
Director of Transportation, OPC

A.P.I.—This is an extended abstract of an address delivered before the general session of the American Petroleum Institute, Chicago, Ill., November 10, 1942.

WAR demands have taken from our shores most of the tank ships which in peacetime furnished the major part of our petroleum transportation, measured in ton-mile deliveries. The Pacific Coast has been affected, but because of shorter distances and lesser volume, it has not been affected as violently as has the East Coast. The normal East Coast delivery route of some 2,200 miles, together with a required daily delivery of something of the order of 1,400,000 bbl., has presented the principal problem in our readjustment program.

We can best grasp the size of this East Coast problem by a realistic view of the volume and distance involved. If we forget about the normal ocean route and limit ourselves to the overland distance involved between the oil sources in the Southwest and the center of consumption on the eastern seaboard, we are dealing with a distance of some 1,500 miles. If we apply to this mileage the objective volume of 1,400,000 bbl. of petroleum per day, or some 200,000 tons per day, we have before us a movement approximating 300,000,000 ton-miles per day.

Naturally, we have turned to tank cars, tank trucks, barges, and pipe lines as the expansible methods through which to accomplish this transformation. During the past 6 months, in the selection of methods, the expansion of which would best serve our objective, many controversial questions have had to be resolved. We have employed certain fundamental principles in appraising these methods. We have applied the rules of the least time required and the least expenditure of critical materials. In an expansion of facilities, we have recognized that more tank cars would require more locomotives; more barges would require more power boats, more canals and canal improvements; more pipe lines would require more available power; more tank trucks would require more rubber.

I should like to touch briefly on some of the projects which are now in the process of construction. Starting with products lines, we are increasing the capacity of the existing Plantation line from Baton Rouge, La., to Greensboro, N. C. In order to provide the line with sufficient supplies, we are building a 60,000-bbl. feeder line from Houston and Port Arthur to Baton Rouge. We are also constructing an extension to this line from Greensboro to Richmond, Va., from which point petroleum products will be moved still farther north and east by barge. The project will not only enable us to assist in supplying the southeastern states, but will also contribute 30,000 bbl. daily to such points as Washington, Richmond and Baltimore.

A new line will soon be built across Ohio designed to deliver at Akron 15,000 bbl. daily to the Sun-Susquehanna line destined for the New York-Philadelphia area. Pending the completion of this Trans-Ohio line, we are moving products to Toledo, then taking them by lake tanker to Cleveland, whence they are transported through the Standard of Ohio and Susquehanna lines into Pennsylvania.

A products line across Florida, with a carrying capacity of 35,000 bbl. daily, is being constructed. Pipe for this project was procured by taking up the American Liberty line in Texas. The Florida line will extend from Carrabelle to Jacksonville. Products moved through this line will be transshipped by barge from Jacksonville, principally for the southeastern states.

The new Sinclair line across southern Pennsylvania to Steubenville, Ohio, is nearing completion. When this line is finished, it will carry products from west to east.

Another combination movement of products to the East Coast will be effected by reversing and converting to products a crude line between Port Arthur and El Dorado, Ark.; reversing an existing products line between Port Arthur and Shreveport, La.; building a short extension in northern Louisiana and connecting it to the Magnolia line into El Dorado; and constructing a new 155-mile line from El Dorado to Helena, Ark. This system will provide a movement of 55,000 bbl. daily. Products will be transshipped from Helena by barge and tank car to points farther north and east.

The Great Lakes Pipe Line Co. in the Middle West is also planning to enlarge its line between Kansas City and Minneapolis, in order to provide additional quantities of fuel oil and gasoline for the northwest area of District 2. A 60-mile 6-in. feeder line connecting three refineries in Oklahoma with the Great Lakes Pipe Line at Barnsdall, Okla., is also under construction.

The looping of the Texas line between Dallas and Stuart, Okla., has been completed. Other important crude-oil pipe-line projects now under construction include looping the Stanolind line between Graford, Tex., and Healdton, Okla.; increasing the capacity of the Stanolind line from Oklahoma to Chicago; looping the Illinois line between Lima and East Sparta, Ohio; installing additional pumping equipment on the Buckeye line across Ohio; reversing the Tuscarora line across Pennsylvania, and making numerous changes in other lines in New York State and Pennsylvania to increase the flow of crude oil to the East Coast. These changes are designed to deliver an additional 40,000 bbl. daily into Chicago of which about 27,000 bbl. daily will reach the East Coast.

Finally, in June of 1942, sufficient steel to build the line from East Texas to southern Illinois was allocated by the War Production Board. Work was started immediately. Seven contractors undertook the building of this line in eight section spreads. It is expected that the pipe laying between Longview and Norris City will be completed by December 10. On October 27, the War Production Board authorized the extension of the 24-in. line to the eastern seaboard and allocated the necessary materials for this construction.

The problem of supply for the War Emergency line at Longview has presented several complications. The general committees for Districts 1, 2 and 3 have been working for several weeks on this matter. It calls for many pipe-line adjustments and reversals. The refining schedules of the Gulf Coast refineries have been affected. It calls for greater use of West Texas oils, as well as oils from the Corpus Christi area of Southwest Texas. In addition to the 8-in. line that is being built by Sinclair Pipe Line Co. from Corpus Christi to Damon Mound, it is apparent that a large crude-oil carrier from Corpus Christi to the Houston area is warranted. Plans are being developed for conversion of one of the large gas lines to an oil carrier from Corpus Christi to Houston to deliver approximately 75,000 bbl. per day.

To augment East Coast supply of necessary winter heating oils, also as an outlet for the war plants of the Gulf Coast, it is now apparent that the War Emergency pipe line will operate in the first quarter of next year on something like 125,000 bbl. per day of heating oil and 175,000 bbl. per day of crude oil. Arrangements are being made by the War Emergency Pipelines, Inc., to batch these oils for transshipment at Norris City. The coastal heating oil and some crude oils will be transshipped to Longview by reversals of one 12-in. and three 10-in. pipe lines with a total carrying capacity of approximately 165,000 bbl. per day.

Pipe-line deliveries prior to the declaration of the national emergency in May 1941 were about 42,000 bbl. daily. Changes brought about thus far have increased those deliveries to nearly 135,000 bbl. daily.

Upon the completion of projects now under construction, other than the War Emergency, it is estimated that deliveries will be increased to 208,000 bbl. daily. This forecast does not include deliveries via the Southwestern line between Port St. Joe, Fla., and Lookout, Ga.

Based on an estimated essential domestic demand in District 1 for the period July 1943 to June 1944, of 1,250,000 bbl. daily, pipe-line deliveries, not including the War Emergency pipe line, will amount to approximately 16½ per cent of total demands. With the War Emergency line completed to the East Coast, the percentage would be 40 per cent.

New proposals, new studies, and new recommendations are being made all the time. Many new projects are now under consideration and details are being worked out to expedite completion. Outstanding among these are the numerous rearrangements necessary to provide an adequate supply of crude oil and heating oil for the 24-in. line.

Our goal is to deliver overland approximately 1,400,000 bbl. daily of petroleum to the East Coast, both for essential domestic supply and offshore demands. Thus far we have been able to increase this overland movement from some 50,000 bbl. daily in peacetime to in excess of 1,000,000 bbl. per day.

A Review of Recent Advances In Drilling-Mud Control

By PRESTON E. CHANEY
Sun Oil Co., Beaumont, Tex.

A. P. I.

A general review of the colloidal chemistry of clays and shales is presented as a theoretical background for the explanation of the various mud problems, and for the chemical treatments used in their correction.

Each of the common mud problems is discussed separately, and an attempt is made to provide a method of diagnosing the cause of trouble from changes in the physical properties of the mud. Following this diagnosis, one or more methods of treatment for correction of the trouble are described, and the theoretical explanation for the action of the corrective treatment is presented wherever possible.

A table showing the combinations of mud properties, or "symptoms" associated with each type of trouble, together with an outline of the corrective treatment, is presented as an aid in rapidly deciding upon the cause of trouble and in selecting the proper treatment.

It is urged that more effort be applied to determination of the cause of mud trouble. A careful study of the results of the various field mud tests is ordinarily sufficient to indicate the impurity-producing trouble, and a method of treatment which eliminates this impurity will give better and more economical results than are obtainable by a trial-and-error treatment to improve certain physical properties of the mud.

Paper presented before Division of Production at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

IN recent years the technique of mud control has made rapid advances. The research engineers of the oil industry, of the universities, and of the commercial mud and chemical companies have sought and found explanations for many of the peculiarities of mud behavior. Consequently they are able to predict more accurately than before the response of mud to various treatments and, in many cases, to avoid trouble as well as to correct it.

Unfortunately, the field mud engineer often does not have the opportunity to study the literature and to perform the experiments necessary to a practical field application of these new discoveries. Consequently there is a gap between the research departments and field practice which delays the advance in field mud-control technique. To the practical mud engineer, the research man often seems too theoretical, and to the research man, the field engineer seems unwilling to accept new ideas. However, it is necessary to efficient operation that these groups cooperate.

In this paper an attempt is made to bridge this gap between laboratory and field practice. The ordinary mud troubles are considered, and an effort made to explain theoretically both the cause of the trouble and the effects of the corrective chemical treatment. The paper has been written primarily from a practical standpoint, and to the research engineer the theoretical phases probably will appear overly simplified. Most controversial points of theory have been omitted in order to avoid confusion, and only those theoretical explanations which, in the author's opinion, best seem to fit the facts are included. All methods of mud treatment suggested in this paper have been used successfully and economically in the field.

It is realized in presenting this paper that criticism will come from both research and field engineers, for the reason that a compromise between the two points of view has been attempted. However, if the paper serves to draw these two groups nearer to mutual understanding, and to further the application of fundamental colloid chemistry in the analysis and treatment of field mud problems, it will have served its purpose.

Daily Field Tests on Drilling Mud

The following tests are essential to any proper estimation of mud condition. They should be conducted daily, or more often in case of trouble. A suitable form, or a place on the daily drilling report, should be provided for reporting the results of these daily tests:

1. *Weight* (pounds per gallon, pounds per cubic foot, or pounds per square inch per 100 ft. of depth).

(Note: Hydrometer or balance should be adjusted to the calibration mark with water at least once per day where weight is critical.)

2. *Viscosity* (Marsh-funnel) (in seconds).

(Note: When commercial weighting materials are used, and in all deep drilling, weight and viscosity should be determined at frequent intervals.)

3. *Sand and total solids* (per cent).

(One sample from pump suction, and one from flow line.)

4. *pH.*

5. *30-minute filter test:* (*a*) Record milliliters of filtrate at end of 30 minutes. (*b*) Record cake thickness (32nds of an inch).

6. *Salt*—reported as parts per million of chloride.

7. *Remarks.* In the daily report, under "remarks," record any mud properties such as high gel rate, gas bubbles, etc., which may be observed from the general appearance of the mud, but which are not indicated directly by the foregoing test results. Also note any tight sections in the hole or other drilling difficulties which might possibly be corrected by suitable adjustments of mud properties.

The American Petroleum Institute has recommended standard methods of conducting the foregoing tests, and detailed procedures may be found in their publication entitled A.P.I. Code 29: "Recommended Practice on Standard Field Procedure for Testing Drilling Fluids," second edition (1942).

Properties of Colloidal Clays and Shales

Inasmuch as such a large proportion of all mud troubles is of chemical origin, it is essential that the field engineer have a working knowledge of the chemistry of colloidal clays. The following discussion of colloidal-clay chemistry is presented only as a review or survey of the literature. For a more complete study of this subject, the reader is referred to the list of references at the end of this paper.

Hydration of Clay Colloids

Colloidal materials may be divided into two general types, according to their action when suspended in water:

The *suspensoids or hydrophobic colloids* have little affinity for water, and only form a stable suspension if the individual particle charge is sufficiently high to prevent coagulation. Such colloids do not swell in water. The emulsoid or hydrophilic colloids, on the other hand, have a strong affinity for water. Each emulsoid particle "hydrates," or sheaths itself in a protective film of water molecules, and a noticeable swelling of clay particles results.

The *bentonitic-clay colloids* belong to this latter class, and most of the common mud troubles are caused by undesirable reactions involving these clay colloids. The bentonitic clays and shales are micaceous in structure; i.e., the individual clay particles are thin flat sheets, stacked in mica-like layers. On one of the flat surfaces of these individual leaflets are attached cations, such as Na^+, H^+, Ca^+, etc. The opposite surface, due to internal structure, is slightly negative with respect to the surface bearing these cations. Consequently there is a weak electrostatic attraction between opposite faces of adjacent particles which serves to bind the plates together.

This bonding force is so weak that water molecules may enter and spread the plates apart. This process is responsible for the swelling of the clay, and the "planar water" so attached comprises a large part of the total water retained by the clay colloids.

This planar water is held in place by the weak residual electrostatic forces of the clay particles. These forces increase with increasing ionization of the clay particles; and it is, therefore, to be expected that the degree of swelling and the amount of water retained by the clays should vary according to the particular alkali or alkaline-earth metal present. The relative degrees of ionization of the more common clay salts decrease in the order Li, Na, K, NH_4, Mg, Ca, Sr, Ba, H, according to Jenny and Reitemeier.[1] Consequently the degree of hydration and the relative stability of the clays decrease in the same order. This means that, for a given clay concentration, a clay containing sodium ions will swell more in water and will have greater stability in general than a clay in which the sodium is replaced by calcium or magnesium.

Clays are known by the predominating positive ion as: sodium bentonite, calcium bentonite, etc. The best drilling clays are practically pure sodium bentonites, inasmuch as these clays can retain relatively larger quantities of water and are more stable and more readily dispersed than the alkaline-earth clays, such as calcium bentonite.

Effect of pH Variation on Clay Colloids

The pH of a solution is defined technically as the logarithm of the reciprocal of its hydrogen-

ion concentration. In simpler terms, we may consider pure water, which has a pH of 7.0, as neutral. The addition of an alkali, such as sodium hydroxide, increases the pH, whereas the addition of an acid will reduce the pH. As the pH of a solution is reduced, the solution becomes progressively more acid; and, as the pH is increased, it becomes progressively more alkaline.

Variations in the pH, or hydrogen-ion concentration, of a clay suspension produce corresponding changes in the physical properties of the suspension. The pH of a suspension of pure hydrogen bentonite, as obtained by electrodialysis, is in the range 2.0 to 3.0. If sodium hydroxide be added slowly to this suspension, the pH will increase, and the hydrogen ions will be replaced by sodium ions up to a pH between 9.0 to 10.0. At this point the hydrogen ions are replaced completely by sodium, and the clay is now a sodium bentonite rather than a hydrogen bentonite.

Garrison and ten Brink[2] have plotted the course of viscosity and gel-rate variations with increasing pH in bentonite suspensions. They found that in the range of pH 4.5 to about 10.5 the viscosity at low rates of shear decreased with increasing pH, and that a minimum in both viscosity and gel rate occurred in the range of pH 9.5 to 10.5. However, Garrison[3] has shown that the ultimate gel strength of the suspension increases with increasing pH. Thus an increased pH tends to reduce the gel rate, but increases the gel strength; whereas a reduction in pH produces the opposite effect. Hence, to a certain extent, it is possible to adjust the relationship between gel rate and ultimate gel strength by pH control.

The mud pH also has an appreciable effect upon the rate of dispersion of shale colloids into the mud system, as has been demonstrated by Garrison, ten Brink, and Elkin.[4] Under the influence of fluid motion the rate of dispersion of shales into the mud stream increases with increasing pH. Therefore, it is possible to increase the yield of natural mud from the shales drilled by maintaining the mud pH in the range of 9.5 to 10.5, rather than in the more usual range of 8.0 to 9.0. On the other hand, when heavily weighted muds are used and trouble is encountered from the rapid accumulation of colloidal material in the mud, it is advisable to reduce the pH to a value between 7.5 and 8.0 in order to retard the rate of shale dispersion.

Also, this treatment is advisable when bentonitic heaving shales are encountered, as a low pH reduces the tendency of these shales to swell and heave into the hole. However, low pH values tend to reduce the gel strength of muds below satisfactory limits, and this fact should be kept in mind whenever pH reduction is contemplated.

Viscosity Relationships of Clay Suspensions

There are at least three factors entering into the viscosity-concentration relationship for any given clay suspensions. These are: (1) The mutual repulsion due to particle charge; (2) the degree of hydration of the colloid particles; and (3) the mutual attraction due to unsatisfied or partly satisfied broken-bond valences.

1. Repulsive forces between clay particles.

The bentonitic clays may be considered as salts having a normal positive ion, such as sodium or calcium, but having an extremely large negative ion, consisting of the remainder of the clay particle. These "salts" are ionized to give a positive (sodium, calcium, etc.) ion, and a negative "bentonite" ion. The degree of ionization and, therefore, the effective negative charge on the bentonite particle, depend on the positive ion with which the particle is combined. Thus a sodium bentonite will have a relatively higher negative particle charge than a calcium bentonite because of its higher degree of ionization. This negative particle charge causes a mutual repulsion between the particles, and tends to reduce particle friction and to prevent the formation of aggregates such as are formed when a drilling mud is flocculated by cement. This effect alone would tend to yield lower viscosities in sodium-bentonite suspensions than in calcium-bentonite suspensions of the same concentration, but the expected reduction in viscosity due to greater repulsive forces in the sodium-bentonite suspension is more than balanced by the increase in viscosity due to the higher degree of hydration.

2. Hydration of clay particles.

The greater degree of ionization and the greater positive-ion hydration of sodium bentonites cause these clays to swell more and to absorb higher percentages of water than the corresponding calcium bentonites. The absorption of water by the clay particles increases their effective diameter, and at the same time inactivates a portion of the water in which the clay is suspended. Both of these effects tend to increase the viscosity of the clay suspension, and are responsible for the fact that higher viscosities are obtained with a given clay concentration using sodium bentonites than with calcium bentonites.

The stability of colloidal suspensions is due to hydration and to the repulsive forces between the individual colloid particles. Any added impurity which tends to reduce the degree of hydration or the particle charge will reduce the stability of the suspension. Thus, when a salt-water flow occurs, the high salt concentration in the drilling fluid serves to dehydrate the clay colloids and to repress their ionization. This reduces the forces stabilizing the suspension and causes flocculation and settling of the clay colloids.

3. Attractive forces between clay particles.

The third factor influencing the viscosity of clay suspensions is that of mutual attraction due to unsatisfied broken-bond valences. As previously explained, the individual clay particles are thin flat sheets, which theoretically could have an unlimited width and length. However, in all natural clays these sheets are broken into sections of very minute width and length. At the surface of this fracture, there are frequently residual valence bonds which originally served to hold the larger sheets together, but which now are left chemically unsatisfied. These residual valences are satisfied in part by the adsorption of water at the broken surface, but there remains a relatively strong attractive force tending to pull another clay particle into a position such that it will form a continuation of the clay sheet and completely satisfy the residual valences of both clay particles. This attractive force between the particles tends to increase the friction between them, and thus increases the viscosity of the clay suspension. Furthermore, when the clay suspension is allowed to remain quiescent for a short time, the particles tend to arrange themselves in a definite pattern and to resist any force tending to destroy this pattern. This latter effect is responsible for gelation, and will be discussed more fully in a subsequent paragraph.

Action of Viscosity-Reducing Chemical on Clay Colloids

The primary effect of viscosity-reducing chemical is believed to be a neutralization of these residual broken-bond valences. By the absorption of certain negative ions at the broken-bond surface, these residual valences are satisfied almost completely. Among those negative ions preferentially adsorbed at the broken-bond surfaces are the tannates, gallates, and the complex phosphate ions, such as hexametaphosphate, pyrophosphate, and tetraphosphate. The adsorption of these ions at the broken-bond surface alters the balance of forces acting between the clay particles from a preponderantly attractive force, due to these residual valences, to a preponderantly repulsive force, due to the normally weaker negative particle charge produced by ionization. As the forces acting between the particles are now preponderantly repulsive, the particles tend to avoid contact with one another. Particle friction, and the tendency to form gel structures, thus are reduced, with a consequent reduction in the viscosity of the clay suspension, or drilling mud.

Gelation of Clay Suspensions

The gelling qualities of a clay suspension are dependent upon the relative attractive and repulsive forces between the clay particles. If the attractive forces due to residual valency are strong and the repulsive forces due to ionization are weak, the mud will have a high gel rate and gel strength. On the other hand, if the repulsive forces are strong, while the attractive forces are weak, the mud will have a slow gel rate and a weak ultimate gel strength.

Any change which tends to alter the relationship between these attractive and repulsive forces will have a pronounced effect upon the gel characteristics of the mud. The addition of small quantities of soluble calcium salts or relatively larger quantities of sodium salts reduces the degree of ionization and, therefore, the negative charge on the clay particles, without materially changing the attractive forces. Consequently the gel rate and gel strength of the mud will be increased. On the other hand, the addition of a complex phosphate, for example, will neutralize the residual broken-bond valences without appreciably reducing the ionization of the clay. Hence the attractive forces are reduced in proportion to the repulsive forces, and a reduced gel rate, gel strength, and viscosity result. In some cases it is difficult to control viscosity by chemical treatment without undesirable reduction in gel strenth. Loomis, Ford, and Fidiam[5] have suggested that under such conditions sodium chloride be added to the mud. The addition of moderate amounts of salt (sodium chloride) reduces the repelling forces between the clay particles, by repressing the ionization, and tends to increase the gel strength. However, this treatment has not been used in the field by the author.

A careful study of the theoretical explanations of mud behavior is helpful to an understanding of the "why" of various mud-treatment methods, and assists in a determination of the proper procedure in handling unusual mud problems.

Common Mud Troubles and Chemical Treatment for Their Correction

The author's experience indicates that, in general, each mud trouble produces certain definite changes in the mud properties that are characteristic of that particular trouble. Therefore, it is usually possible to "diagnose" the cause of any given mud trouble from a careful study of changes in the various mud properties produced by it. In this connection it is important to note that changes in the mud properties, rather than their actual values, are used in this diagnosis. The actual values obtained at any one time from the usual mud tests are important to the drilling operation, but often are not sufficient to enable the engineer to diagnose properly the cause of mud troubles. For example, it is possible to produce a very satisfactory mud having a chloride concentration as high as 5,000 p.p.m. However, if we start with a mud having a chloride concentration of 1,000 p.p.m. and suddenly in-

TO KEEP THE BATTLE MACHINES SLUGGING

Harvester Men Form Maintenance Battalion to Serve the Battle Line

FIGHTING MACHINES, like soldiers, suffer battle casualties. Tanks, trucks, tractors and guns immobilized in combat are useless until repaired.

The men who repair the wounded machines in swiftly-moving armored warfare may tip the scale to victory. Maintenance in the wake of battle calls for soldiers who can grind a valve or handle a tough welding job—men with whom mechanics is second nature.

Army Ordnance, in its quest for men to operate its mobile front-line machine shops, came to International Harvester and suggested the formation of a battalion of mechanical specialists from among Harvester's employes and dealers. Harvester tackled the recruiting job and assumed the expense. Within two weeks the enlistment quota was passed. Now this new maintenance battalion is part of another armored division.

From Harvester factories and service stations, and dealers' shops all over the United States, came mechanics skilled in the building and servicing of machines. They volunteered eagerly to go to the front lines to keep the combat equipment on the field of action.

They will serve with the first such battalion formed from the manpower of a single company. Harvester takes the greatest pride in the speed and enthusiasm with which these hundreds of men volunteered; and in the aptitude of the men now in field training, reported to us by the regular Army officers in command. They are worthy comrades of the 5000 Harvester men who preceded them into military service.

American mechanics are the world's best. They come from the factories, shops and service stations of America—free men—builders of a free land. The Army needs 100,000 more of these men, to be enlisted in many similar maintenance units. Their skills are among our greatest assets in keeping the battle machines slugging for Victory.

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Ave., Chicago, Illinois

INTERNATIONAL HARVESTER

crease the concentration to 5,000 p.p.m., the water loss, gel rate, gel strength, and viscosity will increase beyond satisfactory limits, and the treatment described in following paragraphs for high salt concentrations will be necessary in order to recondition the mud.

In the following paragraphs an effort is made to outline the changes in mud properties characteristic of the various troubles, and to explain the chemical treatments used for their correction after the proper "diagnosis" has been made.

Cement Contamination

One of the most common mud troubles is cement contamination. Usually no "symptoms" are required to locate this trouble, because it may be expected whenever operations require that cement be drilled, and particularly when the cement has not set thoroughly.

Effect of Cement on Clay Colloids

Calcium hydroxide (slaked lime) is present in cement slurries, largely as a result of the hydrolysis of various alkaline calcium silicates and aluminates. The calcium hydroxide so formed is responsible for the observed changes in the mud properties. The calcium ion replaces the sodium on the clay particles, thus converting them to calcium bentonite, while the hydroxyl ion produces a sharp increase in the mud pH. As discussed previously, the calcium clays are not so highly ionized as the sodium clays. Consequently the degree of hydration and dispersion of the clay colloids is reduced. This accounts for the increase in water loss resulting from cement contamination. A further effect of the calcium ion is a flocculation of the clay colloids; i.e., the colloid particles are caused to combine into aggregates of much larger size. Flocculation is responsible for the high viscosity and gel rate of cement-cut muds. The increase is pH, due to hydroxyl ion coming from the slaked lime, tends to increase further the gel strength of the mud, and thus adds to the trouble.

Corrective chemical treatment for cement contamination.

In treating a cement-contaminated mud we must accomplish the following results:

1. Remove the calcium ions as an insoluble precipitate.
2. Reduce the pH to approximate the value before contamination.
3. Redisperse the clay aggregates as much as possible.
4. Replace with fresh clay any colloidal material that cannot be restored readily to its original condition.

In practical application, the first three of these aims are accomplished simultaneously, whereas the fourth is not usually begun until the pH has been reduced to its proper value.

The first treatment consists of a mixture, in about equal proportion, of monosodium orthophosphate and one of the complex phosphates, or of sodium acid pyrophosphate used alone. The complex phosphate acts as a dispersing agent to break up the clay aggregates, whereas the monosodium phosphate removes the calcium and reduces the pH according to the following chemical reactions:

(1)
$$3\,Ca(OH)_2 + 2\,NaH_2PO_4 \rightarrow Ca_3(PO_4)_2\downarrow + 2NaOH + H_2O$$

(2)
$$NaOH + NaH_2PO_4 \rightarrow Na_2HPO_4 + H_2O$$

The first of these reactions is complete before the second begins. It will be observed that sodium hydroxide (caustic soda) is a product of the first reaction and, as this compound is a strong alkali, the pH will not be reduced materially until this reaction has been completed and the second begins. Therefore, by watching for a sharp change in the pH we can tell when all calcium has been precipitated. At this stage in the treatment, the mud usually has a satisfactory Marsh funnel viscosity—although the viscosity is sometimes even lower than desired, but the rapid gel rate makes the mud appear to have a much higher viscosity, and the high water loss remains unchanged. Addition of fresh bentonite may be begun at this stage if the water loss is exceptionally high, but usually it is better to reduce the pH to its original value by continued use of monosodium phosphate (with only enough complex phosphate to maintain desired viscosity) before clay is added. When the pH has been restored to its original value, the use of monosodium phosphate is discontinued; and, as the final step in the treatment, the ordinary viscosity-controlling agents are used to maintain satisfactory viscosity while the bentonitic clay is being added to reduce the water loss and gel rate of the mud to the desired values.

Pretreatment for cement contamination.

When it is known in advance that cement contamination will take place, it is advisable to pretreat the mud with as much monosodium phosphate or sodium acid pyrophosphate as can be added without reducing the pH too low or otherwise damaging the mud. This pretreatment will reduce mud flocculation greatly during cement drilling by precipitating most of the undesirable constituents of the cement before serious damage to the mud has occurred.

Lime, Gypsum, Anhydrite, Etc.

As mentioned in the section on cement contamination, any soluble calcium salt will cause the flocculation of colloidal clays. In normal drilling, sections of lime or limy shale, anhydrite, gypsum, etc., are encountered. These calcium salts are sufficiently soluble to cause trouble from clay flocculation.

Effect of calcium salts on clay colloids.

The characteristics of a mud containing soluble calcium salts depend somewhat on the past history of the mud. One of the peculiarities of clay colloids is the efect of calcium salts on the viscosity. If a soluble calcium salt—for example, calcium chloride—is added to a dry sodium bentonite and the clay then is dispersed in water, the viscosity will be very low for a given clay concentration. On the other hand, if the clay first is dispersed in water and allowed to hydrate, the addition of a calcium salt then will produce a sharp increase in the mud viscosity.

In the first case the clay is converted to a calcium clay before it has had time to hydrate, and the calcium clay does not hydrate so completely as would the sodium clay. Therefore, the clay particles have a smaller effective diameter, and higher clay concentrations would be required to cause the same degree of particle interference in the suspension. On the other hand, if the clay first is hydrated, the individual particles have a large diameter due to the swelling produced by hydration. The addition of calcium then flocculates or coagulates these larger particles, causing them to be attracted by one another. This increases the particle friction, with a consequent increase in viscosity.

Effect of calcium salts on field drilling muds.

In drilling a large shale section containing only moderate amounts of calcium and magnesium salts, the mud will be converted gradually to a calcium-bentonite mud as the original clay is deposited as a filter cake on the walls of the bore hole and is replaced by these calcium or magnesium clays. This will result in a decreased mud viscosity, a fast gel rate, and usually a slight increase in the water loss.

However, when large sections of anhydrite or gypsum suddenly are encountered—as, for example, in drilling the cap material on many shallow domes—a high concentration of calcium is built up rapidly in the mud. This causes flocculation on the sodium clay present in the mud, and results in an increase of gel rate, viscosity, and water loss. It will be noted that, with the exception of the pH, these are the effects produced by cement contamination; and, as the calcium ion is responsible in both cases, we would expect this similarity in effect.

The first set of "symptoms" of calcium contamination ordinarily is encountered only in shallow drilling, with natural muds containing little or no phosphate. In this case, a limy shale section will be found to produce very little mud. The mud produced will have a fast gel rate and a weak gel strength which prevent the proper settling of sand; the viscosity will be abnormally low; and the water loss usually is moderately high. Furthermore, the presence of excess free calcium in the mud will convert to a calcium bentonite any fresh dry clay added to the mud before the clay has had time to hydrate—which would make it necessary to add excessive quantities of clay to obtain the desired increase in viscosity and reduction in water loss and gel rate.

The second set of "symptoms" will be found on any mud when large sections of soluble calcium salts are drilled, and to some degree in drilling limy shale sections with muds containing high concentrations of good clay (low water-loss muds).

Corrective chemical treatment for contamination by soluble calcium salts.

The primary aim of treatment is to precipitate the calcium as an insoluble compound. This may be accomplished by use of disodium phosphate or soda ash, according to the following reactions:

(1)
$$CaSO_4 + Na_2HPO_4 \rightarrow \underset{\text{Insoluble}}{CaHPO_4}\downarrow + Na_2SO_4$$

(2)
$$CaSO_4 + Na_2CO_3 \rightarrow \underset{\text{Insoluble}}{CaCO_3}\downarrow + Na_2SO_4$$

The choice between these two treating agents is based on the pH of the mud prior to treatment. Disodium phosphate produces little or no change in the mud pH, whereas soda ash increases it sharply. Therefore, disodium phosphate should be used if the mud pH is satisfactory, and soda ash is the correct choice if an increase in pH is desired; monosodium phosphate may be used occasionally if the initial pH of the mud is high.

In this connection, it is advisable to review the foregoing discussions of pH. Usually, in drilling limy shale sections with natural mud, little or no mud is formed from the shale. In order to make more mud from the formation, it is desirable to have the pH in the range 9.5 to 10.0. Therefore, in this case soda ash would be the proper selection.

One of the usual viscosity-reducing chemicals must be used along with the soda ash or disodium phosphate in order to maintain a satisfactory viscosity and to disperse the clay colloids, as these chemicals are not effective in viscosity control.

Particularly in the case of natural muds composed largely of calcium shales it will be found that little change in the mud properties is noticeable until the removal of calcium is practically complete. The viscosity will remain low, and the mud will show a fast gel rate and a weak gel strength, up to the time that sufficient soda ash or disodium phosphate has been added to remove the calcium completely. Sometimes this is discouraging, because treatment may be continued for three or four complete circulations of the mud without any noticeable improvement. How-

VICTORY'S CLOAK OF OIL IS A *priceless* ONE

IN ACHIEVING VICTORY, America will owe *much* to oil! Much, because of the research, ingenuity and fortunes expended by the Petroleum Industry. Today, at action's hand, are a host of vital-to-victory essentials... *all from oil!*

Victory's cloak of oil is indeed a priceless one. All America is quickly learning that due to oil our armed forces will not lack rubber,—that high-octane aviation gasoline will never be rationed to our flyers,—that "block-busting" explosives come from Toluene, a petroleum derivative,—that petro-chemical synthetics, like plastics, conserve critical metals.

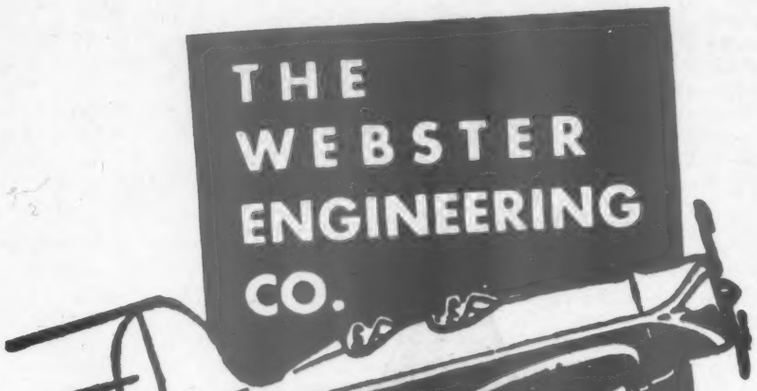
Today, petroleum is also playing a tremendous role in the factories, in the homes, on farms and on foreign fields. In the tomorrow that follows the Peace, Americans will enjoy new comforts of life that will be theirs by virtue of Petroleum's labor.

Closely allied with the Petroleum Industry, as it takes over many added responsibilities, is The Fluor Corporation Ltd., designers and constructors of synthetic rubber, Toluene, aviaton gasoline, alkylation, isomerization, recycling, natural gasoline and gas transmission plants, and petroleum refineries.

SINCE 1890

FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

THE FLUOR CORPORATION LTD.
2500 SO. ATLANTIC BLVD., LOS ANGELES, CALIF.
NEW YORK • PITTSBURGH • KANSAS CITY • HOUSTON



QUALITY
EFFICIENCY
SERVICE *with*
SPEED

Webster combustion equipment is available.

We know how to make oil and gas burning equipment last longer.

Webster burners and controls will not be obsolete after the war.

The services of Webster Combustion Engineers are available to those desiring consultation and assistance, concerning gas and oil burning installations designed to increase out-put.

THE WEBSTER ENGINEERING COMPANY

Division of SURFACE COMBUSTION - - - - - TOLEDO, OHIO

Eastern and Export Representatives:
Oil Field Equipment Co.
30 Church Street, New York, N. Y.

TULSA, OKLAHOMA

West Coast Representatives:
The Natural Gas Equipment Co.
San Francisco and Los Angeles

ever, continued use of the calcium-precipitating agent will give the desired results.

An effort now is being made to develop a satisfactory field test for estimating the calcium concentration in drilling muds. The results of this work, if successful, will be published in the near future.

Gas Cutting

Gas cutting is largely a mechanical, rather than a chemical, problem in mud control. The hydrostatic head of the mud column must be slightly greater than the formation pressure at every point in the hole in order to prevent the flow of formation fluid into the mud system. Gas in the mud indicates that the hydrostatic head of the mud is too low to meet this requirement, and the obvious solution is to increase the mud weight by the addition of commercial weighting materials, such as barytes (barium sulfate).

The addition of weighting material should be begun at the first indication of gas cutting. In this early stage the gas bubbles are very small, and do not rise to the surface of the mud. They are seen best by raking the surface of the mud sample and observing closely for bubbles slightly larger than the point of a pin on the freshly exposed mud surface. This simple test should be performed at frequent intervals when the probability of unusual gas pressures exists; and, if the presence of these small bubbles continues for any length of time, the mud weight should be increased until they disappear.

Corrective treatment for gas-cut muds.

In combating high gas pressures, the viscosity and gel rate of the mud should be kept low by chemical treatment to allow the gas bubbles to break out of the mud, and the fluid should be run over a shale shaker or baffle arrangement to allow escape of the entrained gas. Furthermore, the mud pits should be stirred by mud guns to remove any gas not removed at the shale shaker, in order to prevent recycling of the entrained gas. Modern equipment makes it possible to shut the well in and discharge the mud through a choke, if necessary; but this choke should be used only if the mud is leaving the well faster than the pumps can handle it. The use of a choke puts back pressure on the pumps, and reduces the rate of circulation. This concentrates the gas in a smaller volume of mud, and tends to aggravate the condition.

If weighting material is used, it is advisable to mark the mud level in the pit and observe at frequent intervals for any change. The increase in hydrostatic pressure may cause loss of mud to low-pressure formations. If this occurs before the weight is sufficiently high to hold the gas pressure, suitable measures as discused under "lost returns" must be taken.

Salt Contamination

Occasionally high-pressure salt water or rock salt is encountered in drilling. As the salt concentration rises in the mud, the high concentration of sodium ions represses the ionization of the clays by simple mass action. This destroys the negative charge on the clay particles, and allows the attractive forces to draw these particles together in large aggregates. The first effect is an increase in gel rate, viscosity, and water loss of the mud. Later, as flocculation and dehydration of the colloids continue, the viscosity falls below normal, and the water loss rises in rough proportion to the salt concentration.

Corrective treatment for salt contamination.

The chloride test gives a direct "diagnosis" of salt contamination, but the treatment unfortunately is not so easy. In the case of a salt-water flow, the first step in treatment is to increase the mud weight to the point required to stop the flow. This should be done quickly in order to hold the salt concentration in the mud as low as possible. In drilling rock salt, weighting material is, of course, useless in preventing the salt from rapidly building up to the saturation point in the mud, and on the Gulf Coast it is usually necessary to case off any exposed shale sections if more than a few feet of salt must be drilled.

If the salt concentration in the mud can be held below 7,500 p.p.m. of chlorides, the use of disodium phosphate or soda ash to precipitate soluble calcium salts present in the salt water is usually helpful in reducing the gel rate of the mud. However, this treatment has little effect at higher salt concentrations.

The addition of large quantities of quebracho—sometimes as much as 0.5 to 1 lb. per bbl. of mud—also is recommended for reducing the high gel rate produced by high salt concentrations, and in this case the quebracho may be mixed (about 100 lb. per hour) through the hopper in order to reach the required concentration in the mud system as rapidly as possible.

The ability of colloidal clays to withstand the flocculating effect of salt water increases with increasing clay concentration. Therefore, it is desirable to add large quantities of a highly colloidal clay, preferably hydrated in fresh water before addition to the mud. When high salt concentrations are present, there is little danger of adding too much clay, as the salt dehydrates the clays and prevents the rise in viscosity that would result from the addition of corresponding amounts of clay to a fresh-water mud.

Use of organic colloids in salt-water muds.

Recently much research has been conducted in an effort to find a substitute for the clay colloids in salt-water muds. Various organic colloids such as starch, sodium alginate, and various water-soluble natural gums have been tried. These colloids are more resistant to salt flocculation, but all are subject to bacterial attack, which reduces their effectiveness and produces objectionable odors in the mud. However, preservatives such as phenol, formaldehyde, creosote, etc., have been used recently with these materials in both field and laboratory tests, with very promising results.

As is evident from this discussion, salt contamination is at present the most difficult of all mud problems. The usual mud thinners are practically useless, and a mud that will "get by" is frequently the best obtainable with present methods of treatment. However, it is believed that organic colloids will offer a satisfactory solution to this problem as additional field experience in their use and control is made available to the industry.

Heaving Shale

There are at least three known types of heaving shale and any number of combinations of these types. They are classified as follows:

1. Shale that swells on absorption of the fluid phase of the drilling mud—usually a highly bentonitic shale.

2. Shales containing small lenticular sands or sandy shales charged with gas at high pressure but low volume.

3. Shale that has been compressed and uplifted to an angle greater than normal dip, and under considerable diastrophic strain.

Control of swelling or bentonitic heaving shale.

The bentonitic heaving shales contain clay colloids of the type used in drilling muds. Therefore, any chemical treatment designed to prevent the swelling of these shales is likely to be detrimental to the mud. The presence of bentonitic shale is evidenced by a sharp increase in viscosity and, usually, an appreciable reduction in water loss of the drilling mud. In some cases it is possible to control bentonitic shale by reducing the water loss of the mud to the lowest possible value (less than 6 ml.) and by the addition of sodium acid pyrophosphate, monosodium phosphate, or some other acidic salt to reduce the mud pH to 7.2 to 7.6. As previously mentioned, the dispersion of clay colloids is delayed by low pH values.

If this treatment is not successful in preventing rapid swelling of the shale, a mud containing sodium silicate and saturated salt solution as the fluid phase may be substituted for the normal water-base drilling fluid. The sodium silicate "pickles" the shale, and prevents its swelling or dispersing into the mud stream. Excellent results have been obtained by the use of sodium-silicate muds in several areas where drilling was difficult or impossible with water-base muds.

Control of gas-bearing heaving shale.

Shales containing small lenticular sands or sandy shales charged with high-pressure gas are apt to heave unless the hydrostatic head of the mud column is sufficient to balance the gas pressure. This type of shale usually gives the mud a fluffy appearance and a sour-gas odor, but does not change appreciably any of the other mud properties. Tight places in the hole are often the first definite proof of its presence.

The first step in treating to prevent heaving in this type of shale is to increase the mud weight to the point required to exceed the gas pressure in the sandy lenses. This is not always possible, because the gas pressure may be high enough to cause loss of mud to other exposed formations of lower pressure before the hydrostatic head of the mud is sufficiently high to balance the gas pressure. In this event, the mud weight should be maintained at the highest value possible without serious loss of mud.

The mud viscosity and gel strength should be kept low to prevent swabbing shale into the hole as the drill pipe is removed, and in some cases equipment has been used to permit continuous circulation while coming out of the hole, in order completely to eliminate swabbing action.

Drilling under pressure has been tried in a few cases to combat this type of shale, but the expense and mechanical difficulties involved in pressure drilling with equipment now available usually make it uneconomical to drill and produce oil zones requiring this type of drilling equipment.

Control of plastic-flow type of heaving shale.

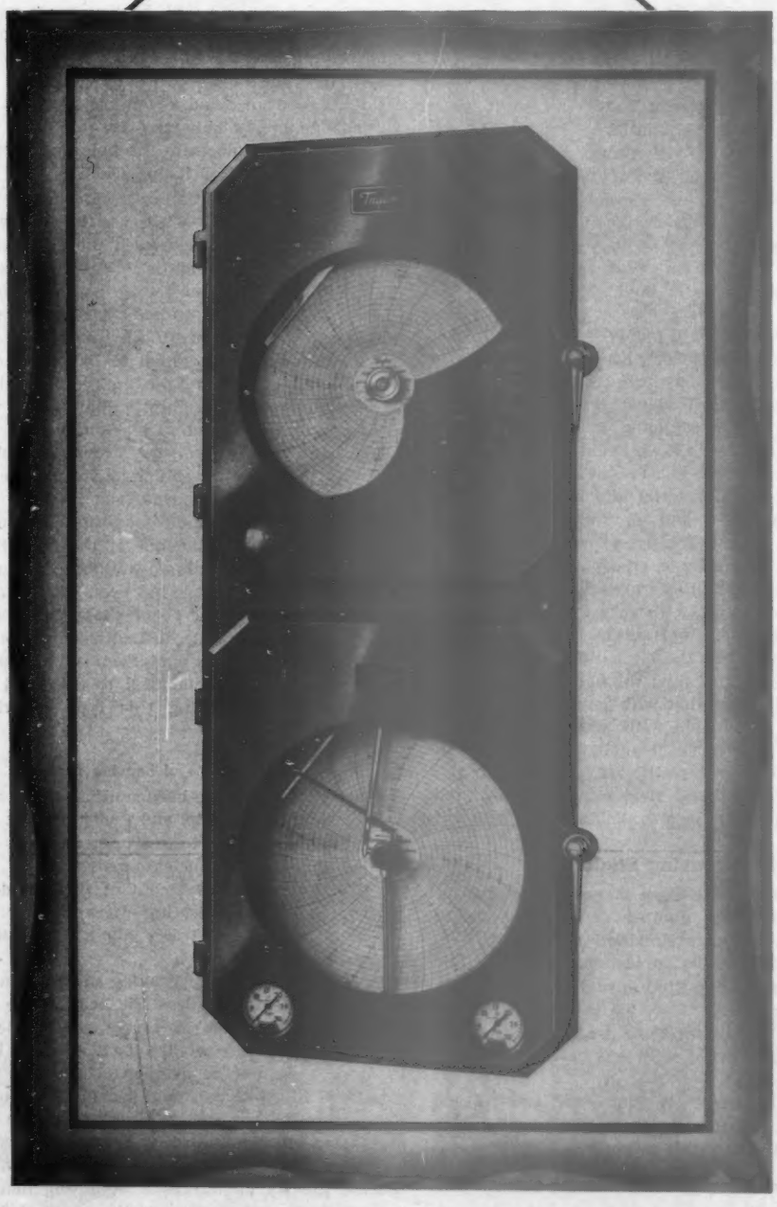
Shale beds that have been uplifted at an angle greater than normal dip, and under present diastrophic strain, are apt to heave, or move by plastic flow into the area of least resistance, i.e., into the drill hole. The movement of these shales is aggravated by the lubricating effect of water from the mud which penetrates along the bedding planes.

To combat this type of heaving shale it is necessary to increase the hydrostatic head of the mud and make it approach as nearly as possible the overburden pressure of the heaving-shale beds. In order to equal the average overburden pressure, a 21.7-lb. per gal. mud would be required. This is beyond the range of weights feasible with present weighting materials. Laboratory experiments on the use of galena (a lead ore with a specific gravity of 7.2) as a weighting material indicate that mud weights of the order of 22 lb. per gal. are possible, but the high cost of this ore probably will prohibit its use in most cases.

A few successful wells have been drilled through heaving shale of this type by the use of low water-loss muds which weigh from 14 to 18

WHY AREN'T THERE ANY PEOPLE IN THIS PICTURE?

BECAUSE TAYLOR TIME SCHEDULE CONTROLLER ELIMINATES THE HUMAN ELEMENT!



Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.

HERE is a new instrument that takes the guesswork out of almost any batch process-control problem!

If the distinctive flavor, color, potency, texture, or other physical characteristics of your product are dependent on following an intricate time-temperature or time-pressure schedule, you can't rely on manual control or the personal judgment of new operators. But you can rely *absolutely* on the Taylor Fulscope Time Schedule Controller!

Once any ideal schedule has been determined, the cam can be cut to coincide with it precisely, so that the same schedule can be reproduced *exactly* every time.

With skilled labor and materials so hard to get, the Taylor Time Schedule Controller is the instrument you need to avoid waste and budget the operator's time most effectively.

PUSH BUTTON CONTROL entirely eliminates manual re-setting of cam at start of cycle.

ADDITION OF INTERRUPTER TIMER permits extreme flexibility of rise, hold, or fall periods in time schedule with the same cam.

DUAL CASE CONSTRUCTION permits easy accessibility to both control mechanism and cam and trip mechanisms.

NUMEROUS AUXILIARY FUNCTIONS can be easily and precisely synchronized with the progress of the processing schedule.

DOUBLE-DUTY form also available for control of two related temperatures, pressures, or flows.

If you haven't already seen this outstanding new Taylor development, get the full story from your Taylor Field Engineer. Call your nearest Taylor office, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

★ KEEP ON BUYING U. S. WAR BONDS AND STAMPS ★

lb. per gal. However, each well of this type is an individual problem, and the required mud weight for successful operations depends upon the degree of residual diastrophic strain in the particular area in question. Pressure drilling can be used to advantage in augmenting the mud weight on wells of this type.

Lost Circulation

The loss of mud to the formation is a trouble encountered frequently when cap material on shallow salt domes is drilled, and in normal drilling with heavy muds.

In the case of cap-rock drilling, the cause of lost circulation usually is a cavity in the rock, and usually it is necessary to set pipe through the zone causing trouble—although in some cases it is possible to plug these cavities by use of a quick-setting cement.

In most present-day drilling, however, the mud is lost to a porous low-pressure sand or gravel bed, and it is usually possible in this case to regain circulation by use of various mechanical plastering agents. Among those most commonly used are shredded cellophane, sugar-cane fibers, and mica flakes. These materials are added to the mud in the pit, and are pumped down opposite the zone to which the mud is being lost. Usually best results are obtained by the use of a combination of these materials.

It is necessary to remove the shale-shaker screens or to bypass the shaker in order to circulate these materials; for this reason it is undesirable to leave such materials in the mud for any great length of time. The usual procedure is to drill for 12 to 24 hours after circulation has been regained, and then to remove these materials by means of the shale shaker.

Also, the gel strength of heavily weighted muds should be kept low to prevent breaking down of the formation by the pump pressure required to break the gel and start circulation after a trip. If lost circulation has already occurred or is considered likely, it is advisable, on every trip with the drill pipe, to break circulation one or more times before reaching bottom in order to break the mud gel and reduce the initial pump pressure required to circulate on bottom.

When lost circulation has occurred, it is often possible, by the use of shredded cellophane, mica flakes, etc., to make the formation support a mud weight equal to that which originally caused the breakdown. However, in most cases this mud weight is very close to the upper limit. A small increase in mud weight above this point quite often produces a second breakdown which is more difficult to seal than the first. Therefore, it is advisable to set casing through the zone taking mud if further weight increases are anticipated.

Preventive measures.

On the Gulf Coast of Texas and Louisiana there are thick beds of sand in the Miocene which have been found by experience to take mud under moderate pressures. Consequently, it is advisable to set a protective string of casing through the Miocene sand beds whenever it is necessary to use a mud weighing more than 13 lb. per gal. in drilling the deeper formations.

It also has been found in certain areas where lost circulation in a definite zone has occurred on previous locations that a pretreatment with small quantities of the usual plastering agents is of value. The usual procedure is to add a few hundred pounds of the plastering agent to the mud just prior to drilling the zone in which lost circulation is expected. Circulation of the plastering agent is continued for about 24 hours after drilling the zone, after which the shale-shaker screens are replaced and the plastering material removed.

The explanation offered for this procedure is that it is easier to plaster crevices in the formation before a breakdown occurs than it is to seal off a zone already taking mud. In some cases this procedure seems to have merit. However, it is often not possible to anticipate the occurrence of lost circulation, as is necessary to this procedure.

High-Temperature Decomposition of Phosphates

Many of the viscosity-reducing chemicals now in common use depend for their effect on the dispersing action of the complex phosphates. These complex phosphates are salts obtained from the simple (ortho) phosphates by dehydration. Tetrasodium pyrophosphate, for example, may be produced by the following reaction:

$$2\ Na_2HPO_4 \xrightarrow{\text{Heat}} Na_4P_2O_7 + H_2O$$

Unfortunately, this reaction is reversible in the presence of water, and the rate of reversal increases rapidly with temperature within the range of normal mud temperatures. Hence, in very deep wells, or in drilling near shallow salt domes, when abnormal temperatures are encountered these complex phosphates are decomposed almost completely in one circulation of the mud, and constant additions of relatively large quantities of the complex phosphates are required to keep the viscosity within satisfactory limits. Furthermore, the decomposition products of some of the more common complex phosphates are strongly acidic, and tend to reduce the pH of the mud below desirable limits.

The flow-line temperature may be used as a rough measure of the bottom-hole temperature in deciding when to expect this trouble, as these two temperatures vary in more or less direct proportion. However, the spread between the bottom-hole and flow-line temperatures increases with the depth of the hole. Hence, high-temperature decomposition of the phosphates normally will occur at lower flow-line temperatures on deep wells than on shallow wells. In general, a flow-line temperature of 120° F., or above, indicates a bottom-hole temperature sufficiently high to cause this trouble.

Corrective chemical treatment for high-temperature decomposition of phosphate.

In the early stages, a mixture of equal proportions of quebracho extract and one of the phosphates sometimes will maintain a satisfactory viscosity, and the use of quebracho has the added advantage of reducing the water loss of the mud. However, quebracho is capable of reducing the initial and 10-min. gel-strength values so low as to allow settling of cuttings and weighting material on muds having a low pH; and, as the decomposition products of many phosphates tend to lower the mud pH, this mixture must be used with caution. The use of salt as suggested by Loomis, Ford, and Fidiam[8] probably would be of advantage in maintaining satisfactory gel strength under these conditions, but the author knows of no case in which salt has been used.

An organic compound, dicyandiamide, for use in high-temperature muds recently has been placed on the market.[9] This compound, $NH_2C(:NH)\ NH\ C:N$, is said to stabilize the phosphates as well as to reduce the viscosity and gel strength of high-temperature muds. As this chemical has been in use only a short time, much remains to be learned of its reactions. However, very satisfactory results have been obtained by its use in combination with the phosphates and quebracho on some of the deep wells recently drilled on the Gulf Coast of Texas and Louisiana. The procedure recommended by the manufacturers is to add dicyandiamide rapidly to a mud already containing phosphates, up to a concentration of about 0.5 lb. per bbl. of mud, and then to use a combination of phosphates, or quebracho, and dicyandiamide as required to maintain satisfactory viscosity.

Dicyandiamide, like quebracho, has been known to reduce the gel strength below desirable limits when too much was used. Therefore, the gel rate and gel strength should be observed carefully during its use.

Phosphorus and the phosphates are used extensively in modern warfare. Therefore, it is quite possible that the industry may be unable to obtain the necessary supply of phosphates for mud control in the future. In that event, it will be necessary to make more extensive use of organic materials such as dicyandiamide, gallic acid, and quebracho as substitutes for the complex phosphates, and to use sodium bicarbonate or soda ash where we now use the simple orthophosphates.

High Concentration of Colloidal Matter

In the course of drilling, beds of bentonitic shale sometimes are encountered which disperse rapidly into the mud system and increase the viscosity and total solids content of the mud. The rate of dispersion may not be high enough to place them in the class of bentonitic heaving shales, but the accumulation of colloidal material makes viscosity control difficult.

Dilution with water will reduce the viscosity of any drilling mud, and it is, therefore, a temptation for the field engineer to control difficult muds by excessive use of water rather than by proper chemical treatment based on a correct diagnosis of the actual cause of the trouble. Water is a very expensive "chemical" to use on heavily weighted muds. For example, it requires about 600 lb. of barytes to increase the weight of 1 bbl. of water to 16 lb. per gal., whereas the cost of chemicals required to produce the same viscosity reduction is usually much less. We should make certain that the colloid concentration is too high before adding the large volumes of water and weight material necessary to correct it.

Prevention by pH control.

Frequently the high concentration of colloid material may be prevented in part on heavy muds by proper chemical treatment *before* the bentonitic shale is encountered. As mentioned previously, the rate of dispersion of shales into the mud stream increases with increasing mud pH, showing a sharp increase in the range of pH 9 to 11 for most shales. Therefore, it is important in drilling bentonitic shales with heavily weighted muds to adjust the pH of the mud system within the range of pH 7.5 to 8 in order to retard the dispersion of bentonitic shale as much as possible. pH values lower than 7.5 probably would further reduce the rate of shale dispersion, but are not recommended because of the instability of acid muds and the increased corrosion of the drill pipe. A pH range of 8.0 to 9.5 is recommended for all ordinary drilling, but the lower pH values are useful when heavily weighted muds must be used.

Corrective chemical treatment for high concentration of colloids.

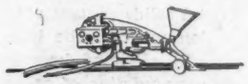
Muds containing excessive amounts of bentonitic shale will show a high viscosity with a *low water loss*. If the water loss is relatively high, the trouble is probably due to soluble calcium salts rather than to excessive amounts of bentonite, and the treatment should be selected accordingly. The only successful treatment for excessive con-

SEWING MACHINES FOR STEEL

(Reading Time—35 seconds)

A few years ago, all arc welding was a time-consuming, "hand-sewn" job. Long continuous welds involved hours of hard work. Heavy metals could only be welded by piling one bead on top of another until the seam was full.

. . .



Today, urgent demands for speed are met by Unionmelt*, an *automatic* welding process which stitches steel together 20 times faster than any other method . . . half-inch steel plates are welded at the rate of 18 inches a minute.

. . .

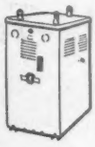
Like thread from a spool, bare electrode is fed to the seam automatically. Welds are flat, dense, and uniformly sound.

. . .

Unionmelt is one of the reasons ships are sliding down the ways months ahead of schedule . . . one of the reasons railroad car manufacturers and boiler companies are beating delivery promises.

. . .

To supply the steady flow of heavy current needed, most Unionmelt users choose Westinghouse A.C. Transformer Welders . . . because the two are made for each other. Together, they form an unbeatable team for single-pass welding of 1/16" to 2 1/2" steel plates.



. . .

**Registered Trade-mark of The Linde Air Products Co.*

. . .

Find out how you can use this ideal combination in your plant. Write for booklet B-3090.

Westinghouse Electric & Mfg. Co.

Dept. 7-N, East Pittsburgh, Pa.

J-70393

centrations of bentonite is dilution with water and the addition of weight material to maintain the required mud weight. This is an expensive treatment, but is necessary if large sections of bentonitic shale are encountered.

Conclusions

An attempt has been made to rationalize the causes and "cures" of various mud problems on the basis of theoretical considerations. It is believed that a more thorough application of the fundamental principles of colloid chemistry in the field treatment of drilling muds, as opposed to the more common trial-and-error methods of the past, will pay dividends in economical and less troublesome drilling operations.

Often a treatment which gives temporary relief from a particular mud problem may itself cause more serious difficulties at a later date. Therefore, an attempt should be made to look ahead in mud treatment, and to prevent the occurrence of trouble whenever possible. Credit is due the engineer who quickly and economically can correct mud troubles which endanger or delay the drilling operation, but even greater recognition should be given to the less spectacular efforts of those who, by foresight, avoid these costly delays and difficulties.

Closer cooperation between the research and the field engineers is necessary if rapid improvement in field mud-treatment methods and the fullest utilization of research data are to be achieved.

Appendix

The following is an outline of the ordinary mud troubles, their "symptoms," and the methods of treatment most commonly used for their correction. There is included also a list of the most common mud-treatment chemicals, with their pH values in the concentrations ordinarily used in mud treatment. This list of chemicals was furnished by Arthur G. Levy, of Fohs Oil Co., and is presented with his kind permission.

CEMENT CONTAMINATION

Symptoms

1. Increased gel rate and gel strength.
2. Increased pH.
3. Increased viscosity.
4. Increased water loss.

Chemical Treatment

1. Mixture of monosodium phosphate and complex phosphate, or sodium-acid pyrophosphate alone, until pH returns to value, before contamination.
2. Add colloidal clay slowly, with continued use of complex phosphate to control viscosity, until water loss and gel rate return to normal.

SOLUBLE CALCIUM SALTS

(Lime, gypsum, anhydrite, etc.)

A. In drilling limy shales with natural drilling mud:

Symptoms

1. Mud viscosity usually low.
2. Rapid gel rate, weak gel strength.
3. Practically no new mud formed from shales drilled.

Chemical Treatment

1. Add soda ash (alkaline), or disodium phosphate (neutral), depending on initial pH, until viscosity begins to rise. There will be little if any improvement in mud properties until treatment is practically complete. Then viscosity and gel characteristics improve rapidly.
2. If gel rate is still too high after viscosity increases to desired value, use mixture of soda ash or disodium phosphate with sufficient complex phosphate to control viscosity until gel rate is satisfactory.
3. Colloidal-clay additions may be required to give satisfactory wall-building characteristics.

B. In drilling beds of gypsum, anhydrite, etc. (large quantities of soluble calcium salts suddenly encountered):

Symptoms

1. Increased gel rate and gel strength.
2. Increased viscosity.
3. Increased water loss and cake thickness.

Chemical Treatment

1. Use mixture of disodium phosphate and complex phosphate to remove calcium and control viscosity.
2. Add fresh bentonite as required to hold required water loss.
3. Quebracho useful in reducing gel rate.

HIGH-PRESSURE GAS

Symptoms

1. First indicated by minute gas bubbles which do not readily break out of mud. Best seen by raking surface of mud sample and observing for bubbles at freshly exposed surface.
2. More severe stages:
   (*a*) Strong gas odor at flow line.
   (*b*) Gas pockets cause mud to flow by heads.
   (*c*) Distillate forms emulsion with mud, which reduces effectiveness of chemical treatment.
   (*d*) Volume of mud in pit increased just before blowout, indicating that mud is leaving hole faster than pumps can handle it.

Chemical Treatment

1. At first definite indication of gas put guns on pit and start mixing weighting material to overcome gas pressure. Increase chemical treatment to reduce viscosity and gel rate of mud. Mark level of mud in pit, and observe frequently for any increase or decrease in mud level.
2. In extreme cases, close blowout preventers and put mud discharge on choke. Choking mud discharge should be done only when absolutely necessary, as this slows circulation of mud and thereby concentrates the gas in a smaller volume.
3. Immediate action is the best solution to gas cutting. Any unnecessary delay in increasing mud weight causes recirculation of gas-cut mud and increases the danger of blowout.

HIGH-TEMPERATURE DECOMPOSITION OF PHOSPHATES

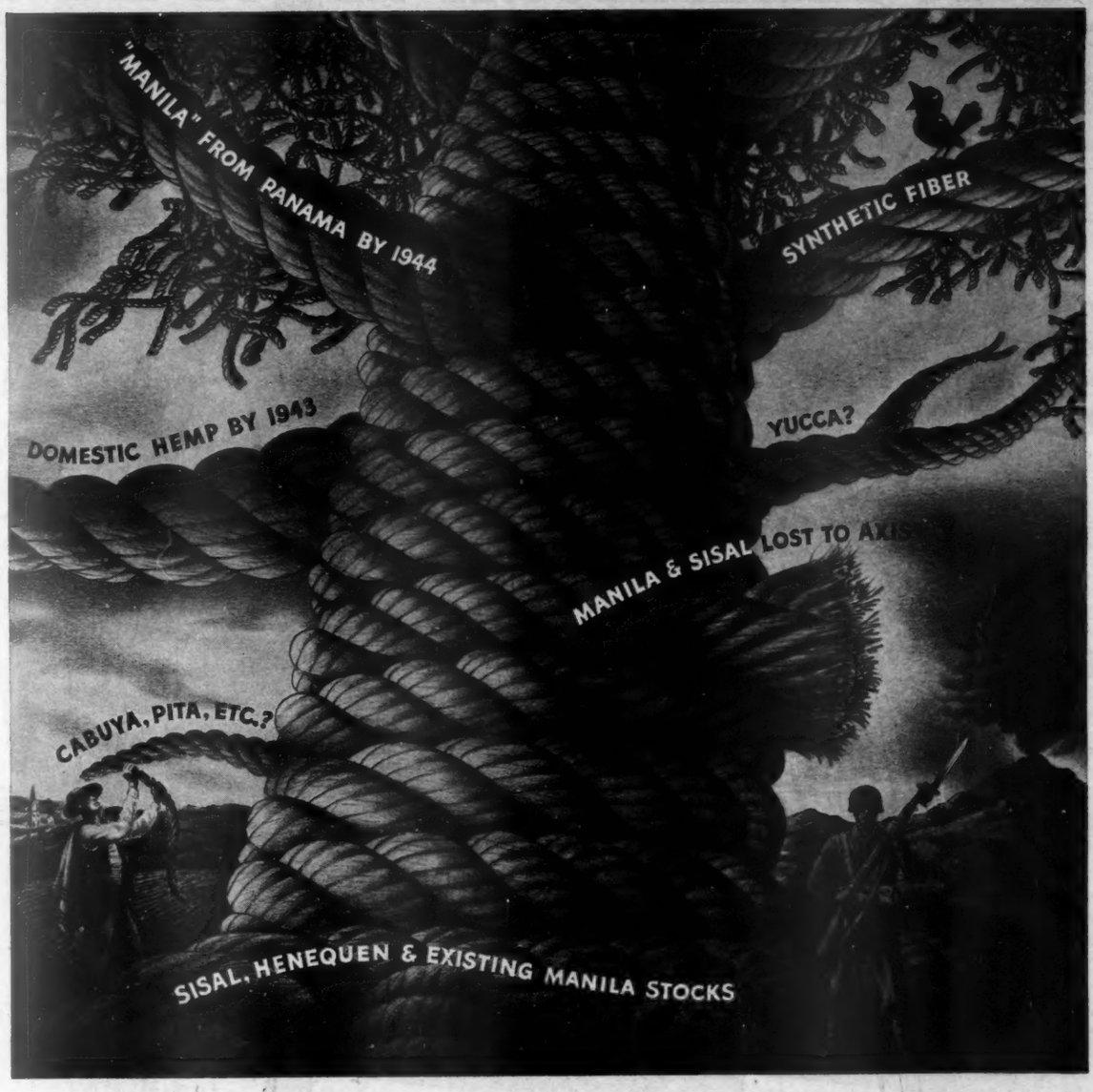
Symptoms

1. Temperature at flow line, 120° F. or higher.
2. Viscosity of mud high despite continuous additions of phosphates.

Chemical Treatment

1. Use Quebracho in equal proportion with phosphate.
2. If above not successful, use dicyandiamide. To be added rapidly to a concentration of 0.5 lb. per bbl. of mud, followed by addition of a mixture of dicyandiamide with complex phosphate or quebracho as required to maintain satisfactory viscosity.
3. Excessive use of this compound sometimes produces objectionable reduction in gel strength of mud.

(Continued on Page 94)



New Branches on the Rope Family-Tree

The U. S. Rope Industry, built since clipper ship days on fiber lines which stretched around the world, is changing from a global to a hemispheric operation in the havoc of World War II.

Two great facts have created two great needs in this essential war industry.

Fact 1: Jap invasion and Nazi submarines have stopped or threatened approximately 90% of the normal rope making fiber shipments (including *all* of the Manila fiber used in oil field cordage).

Fact 2: Rope on direct war orders (not including normal civilian requirements) now *exceeds* the pre-war annual production of rope.

Need 1: Fiber conservation by rope and twine users, through better care, and *minimum* buying.

Need 2: New sources of supply for fiber to augment sisal, Mexican henequen, and existing Manila stocks.

The Rope Family-Tree shows the following important new fiber possibilities which government and private business are busy exploring and developing.

Domestic hemp — Kentucky farmers are raising 350,000 bushels of seed this year, which will sow 400,000 midwestern acres—expected yield for 1943 is 200 million pounds of cordage fiber.

"Manila" from Panama — a new Caribbean crop grown from Abaca (banana) seedlings. The size of the first crop (in 1944) is a military secret.

Synthetic fibers — Plymouth laboratories have pioneered synthetic rope research, with promising results (also a military secret). No great quantity of synthetic rope is anticipated for civilian use for some time.

Yucca, a U. S. desert plant, *Cabuya* from Ecuador, *Pita* from Colombia, *Caroa* and other wild Brazilian plants, may come to the aid of our shrinking fiber pile, if current tests prove favorable.

Meantime, save rope, save twine—buy only what you need.

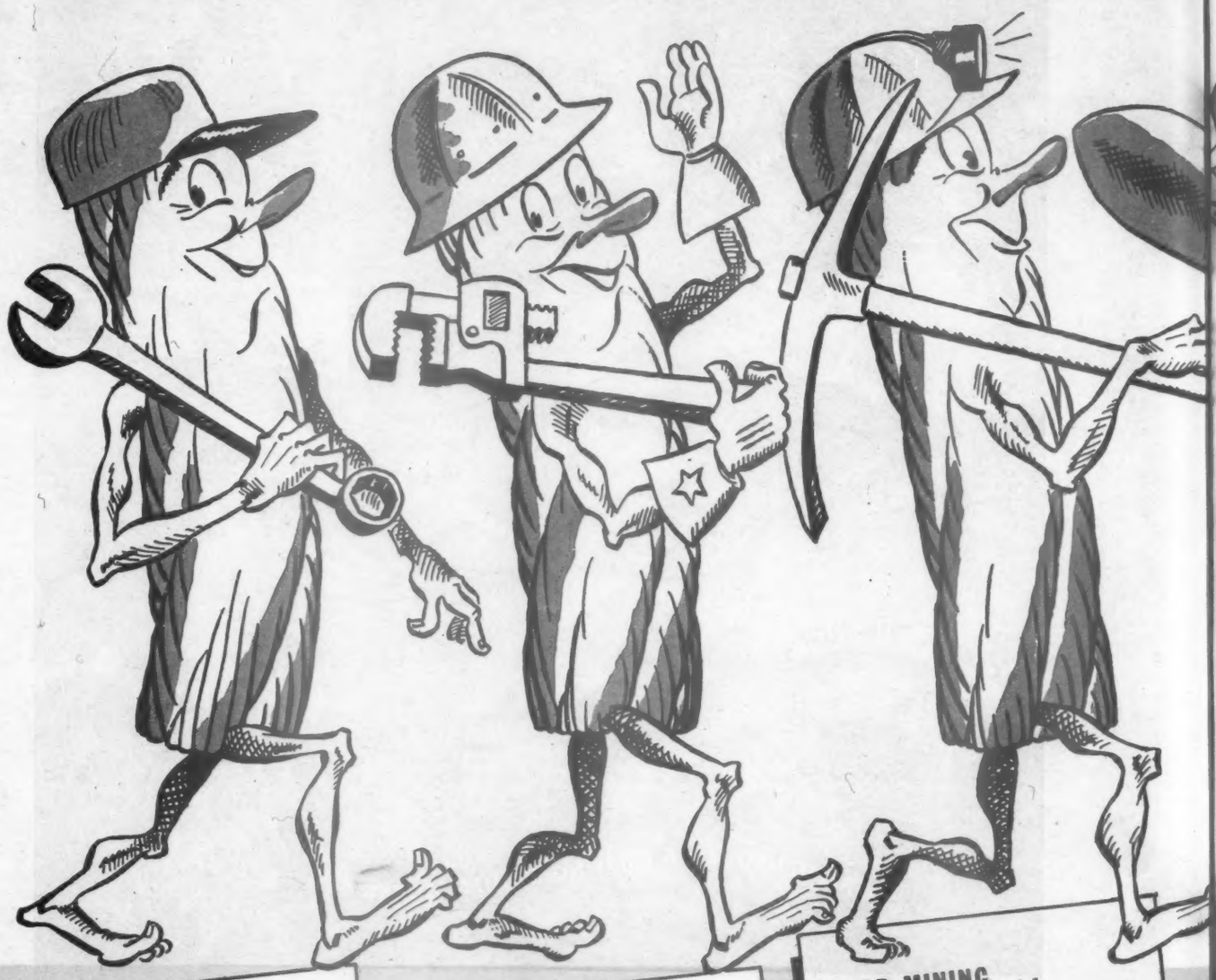
Plymouth Cordage Company, World's Largest Manufacturer of Fine Rope and Binder Twine.

PLYMOUTH CORDAGE COMPANY

North Plymouth, Massachusetts

Distributors: Oil Well Supply Company. Stores in all fields.

The American Tiger Brand



FOR ELEVATORS . . .

For years American Tiger Brand 8 x 19 Seale Patent Traction Steel Elevator Rope has established remarkable mileage records on hard-working elevators all over the country. Its construction provides a greater surface contact tending to minimize slippage, and it is particularly designed to give maximum resilience, flexibility and tractive effort. This rope is manufactured to withstand hard, continuous duty — a feature especially important right now.

FOR OIL AND GAS . . .

No one needs to tell an oil man how important good wire lines are in keeping his drilling operations running smoothly. In American Tiger Brand Wire Lines, we produce wire lines that have earned their high reputation in the oil fields by actual performance — on a proved ability to meet every demand put upon them as oil wells go down deeper and faster than ever before!

FOR MINING . . .

Because of its strength and superior fatigue-resisting properties, American Tiger Brand Wire Rope will improve operations wherever used. On the mechanized equipment used in mining, where ropes are handled frequently, overwind on drums, bend around small sheaves and are subject to excessive loads under adverse conditions, this rope gives long and trouble-free service.

USS UNITED STATES

Army is on the march...

FOR CONSTRUCTION...

Check over in your mind the important equipment that requires wire rope for its operation — shovels, draglines, cranes, derricks, scrapers, to mention a few. Then think of the vital part such equipment is playing right now in the construction of war-time facilities. This means that good wire rope like American Tiger Brand is indispensable for the success of our war program.

Indispensable to America's War Effort . . .

GOOD WIRE ROPE!

Excellay Preformed

TAKE CARE OF WHAT YOU HAVE, USE IT PROPERLY AND MAKE IT LAST LONGER. We believe this advice is important to every user of Wire Rope. We have prepared a 48-page booklet of Valuable Facts on Wire Rope Care that will improve performance and definitely extend its useful life. A copy in the hands of your operating men will save money for you and, in addition, will help conserve wire rope supplies for other vital national requirements. Send for your copy. ***Remember, a broken rope is a break for the enemy.***

AMERICAN STEEL & WIRE COMPANY
Cleveland, Chicago and New York

COLUMBIA STEEL COMPANY
San Francisco

United States Steel Export Company, New York

STEEL

(Continued from Page 90)

ROCK-SALT OR SALT-WATER FLOW

Symptoms

1. Rapid increase in salt content of mud.
2. First effect is increased gel rate and viscosity. After several hours, or perhaps a day, viscosity drops below normal.
3. Water loss increases rapidly.
4. In case of salt-water flow, mud continues to flow after pumps have been shut down.

Chemical Treatment

1. In case of salt-water flow, increase mud weight as rapidly as possible until shutoff is obtained, but watch closely for loss of mud to the formation, and stop weight increase if this occurs (even though some flow of water continues) until mud loss is stopped by addition of plastering agents.
2. In extreme cases, pull up in casing to condition mud, as the danger of stuck drill pipe is serious when salt water is encountered.
3. Add large quantities of highly colloidal clay, preferably hydrated in fresh water before addition to the mud.
4. Copious additions of quebracho are sometimes helpful in reducing "salt-water gel."
5. In severe cases, substitute organic colloids for clay in mud.

HEAVING SHALES

A. Bentonitic heaving shale:

Symptoms

1. Increase in mud viscosity and gel strength.
2. Reduction in water loss and cake thickness.
3. Tight places in hole.

Chemical Treatment

1. Reduce water loss to lowest possible value.
2. Reduce mud pH to 7.2 to 7.6 by use of pyrophosphate.
3. Low pH muds tend to have very low gel strength. Do not reduce pH low enough to prevent suspension of weighting material and cuttings.
4. Keep mud viscosity and gel as low as possible to prevent swabbing.
5. Use sodium-silicate mud in very severe cases.

B. Gas-bearing heaving shale:

Symptoms

1. Sour-gas odor at shale shaker.
2. Little increase in viscosity unless bentonitic shale is also present.
3. Tight places in hole.

Chemical Treatment

1. Reduce water loss of mud.
2. Increase mud weight until difficulty is stopped or until loss of mud to formation begins.

C. Plastic-flow heaving shale:

Symptoms

1. Large slabs of shale circulated out of hole.
2. Shale may flow into hole to a height of a hundred or more feet on removal of drill pipe.
3. Stuck drill pipe or tight places in hole.
4. Usually found on highest part of structure.

Chemical Treatment

Same as for "B."

CAVITY, OR HIGHLY POROUS FORMATION

Symptoms

1. Partial or complete loss of mud returns.

Chemical Treatment

1. If rate of mud loss is low, allow viscosity to increase slightly, but keep gel strength low.
2. In more severe cases, use mechanical plastering agents such as cellophane, mica flakes, etc.
3. If cavity, usually necessary to set pipe before normal drilling operations are resumed.

HIGH CONCENTRATION OF COLLOIDAL MATTER

Symptoms

1. Viscosity high, and not improved by chemical treatment.
2. Low water loss.
3. Usually high total-solids content.

Chemical Treatment

1. Reduce mud pH to less than 8.0, but not less than 7.2, by use of monosodium phosphate or sodium-acid pyrophosphate. Watch gel strength of mud in reducing pH, as it tends to become too low to support weighting material and cuttings.
2. Alternate the use of the various chemicals available for viscosity control.
3. Dilute with water and maintain weight by addition of weighting material, if necessary.

COMMON CHEMICALS IN USE FOR VISCOSITY CONTROL

(Compliments of Arthur G. Levy)

The following list of chemicals in use for viscosity control of drilling muds is arranged in order of pH values, varying from a low of 1.5 to a high of 12.6—depending somewhat upon concentration.

Chemical—	Formula	Approx. pH
Phosphoric acid	H_3PO_4	1.5
Gallic acid	$C_7H_6O_5$	3.4
Sodium acid pyrophosphate	$Na_2H_2P_2O_7$	4.8
Crude tannic acid	$C14H_{10}O_9$	5.0
Chestnut extract	$C14H_{10}O_9$	6.4
Sodium hexametaphosphate	$(NaPO_3)_6$	7.0
Sodium bicarbonate	$NaHCO_3$	8.2
Disodium phosphate	Na_2HPO_4	8.6
Sodium tetraphosphate	$Na_6P_4O_{13}$	8.7
Borax	$Na2B_4O_7$	9.1
Tetrasodium pyrophosphate	$Na_4P_2O_7$	9.9
A mixed soda	$Na_2CO_3.NaHCO_3$	10.1
Soda ash	Na_2CO_3	11.0
Trisodium phosphate	Na_3PO_4	11.3
Sodium metasilicate	Na_2SiO_3	11.6
Caustic soda	NaOH	12.6

Many of the foregoing chemicals are marketed under trade or proprietary names, either in the pure state or together with small additives, which slightly change the formula or the pH, or both. These changes are usually of small importance, and have little or no value in practical use.

The pH values given above are for the concentrations which are most common in oil-field use.

References

1. H. Jenny and R. F. Reitemeier, "Ionic Exchange in Relation to the Stability of Colloidal Systems," J. Phys. Chem. 39, 593 (1935).
2. A. D. Garrison and K. C. ten Brink, "A Study of Some Phases of Chemical Control in Clay Suspensions," Trans. Am. Inst. Mining Met. Engrs. 136, 175 (Tech. Pub. 1124) (1940).
3. A. D. Garrison, "Surface Chemistry of Clays and Shales," Trans. Am. Inst. Mining Met. Engrs. 132, 191 (Tech. Pub. 1027) (1939).
4. A. D. Garrison, K. C. ten Brink, and P. B. Elkin, "Dispersion of Clays and Shales by Fluid Motion," Trans. Am. Inst. Mining Met. Engrs. 136, 195 (Tech. Pub. 1125) (1940).
5. A. G. Loomis, T. F. Ford, and J. F. Fidiam, "Colloidal Chemistry of Clay Drilling Fluids," Trans. Am. Inst. Mining Met. Engrs. 142, 86 (Tech. Pub. 1201) (1941).
6. R. B. Booth, U. S. Patent No. 2,280,996, assigned to American Cyanamid & Chemical Co.
7. C. E. Reed, "Recent Advances in Knowledge of the Colloidal Properties of Clay Suspensions and Gels," Trans. Am. Inst. Mining Met. Engrs. 127, 240 (1938).
8. H. T. Byck, "Effect of Temperature on Plastering Properties and Viscosity of Rotary-Drilling Muds," Trans. Am. Inst. Mining Met. Engrs. 136, 165 (Tech. Pub. 1116) (1940).
9. G. R. Gray, J. L. Foster, and T. S. Chapman, "Control of Filtration Characteristics of Salt-Water Muds," Am. Inst. Mining Met. Engrs. Tech. Pub. 1351 (1941).
10. H. H. Denton, "Abnormal Salt-Water Pressures on the Texas and Louisiana Gulf Coast," unpublished report (1940).
11. A.P.I. Code 29: "Recommended Practice on Standard Field Procedure for Testing Drilling Fluids," 2d ed. (tentative), July (1941).
12. M. Williams, "Radial Filtration of Drilling Muds," Trans. Am. Inst. Mining Met. Engrs. 136, 57 (Tech. Pub. 1112) (1940).
13. M. Williams and G. E. Cannon, "Evaluation of Filtration Properties of Drilling Mud," Drilling and Production Practice, Am. Petroleum Inst., 20 (1938).
14. G. Wade, "Review of the Heaving-Shale Problem in the Gulf Coast Region," U. S. Bur. Mines Report, Investigation 3618 (1942).
15. H. T. Byck, "The Effect of Formation Permeability on the Plastering Behavior of Mud Fluids," Drilling and Production Practice, 40 (1940).

Care and Use of Rubber And Oilskin Clothing

WE have three types of this equipment: oilskins; outside-surfaced rubber suits; inside-and-outside-surfaced rubber suits.

Oilskin suits are to be used as protection from rain and moist snow, or when subjected to contact with petroleum oils and greases.

Single coated, outside-surfaced rubber suits are to be used by employes who are continually subjected to acid exposure.

A large quantity of each of these suits is on permanent holdouts and are returned to the tool department when no longer needed by employe, due to change of job or separation or when there is need for replacement. The care of these clothes is the direct responsibility of the person having them. Clean the clothing after each use. All clothes issued daily by the tool department are cleaned and sterilized after each use.

The single-coated rubber suits cost 20 per cent more than oilskins and the double-coated rubber suits cost over 100 per cent more.

Do not subject rubber suits to petroleum products as this causes rubber to blister and peel from fabric surface and decreases the life of rubber suits to less than that of oilskins, in like service.

Do not wear suits open. Keep buttoned at all times to eliminate the hazards of catching on objects. Open clothing is especially dangerous around moving objects.

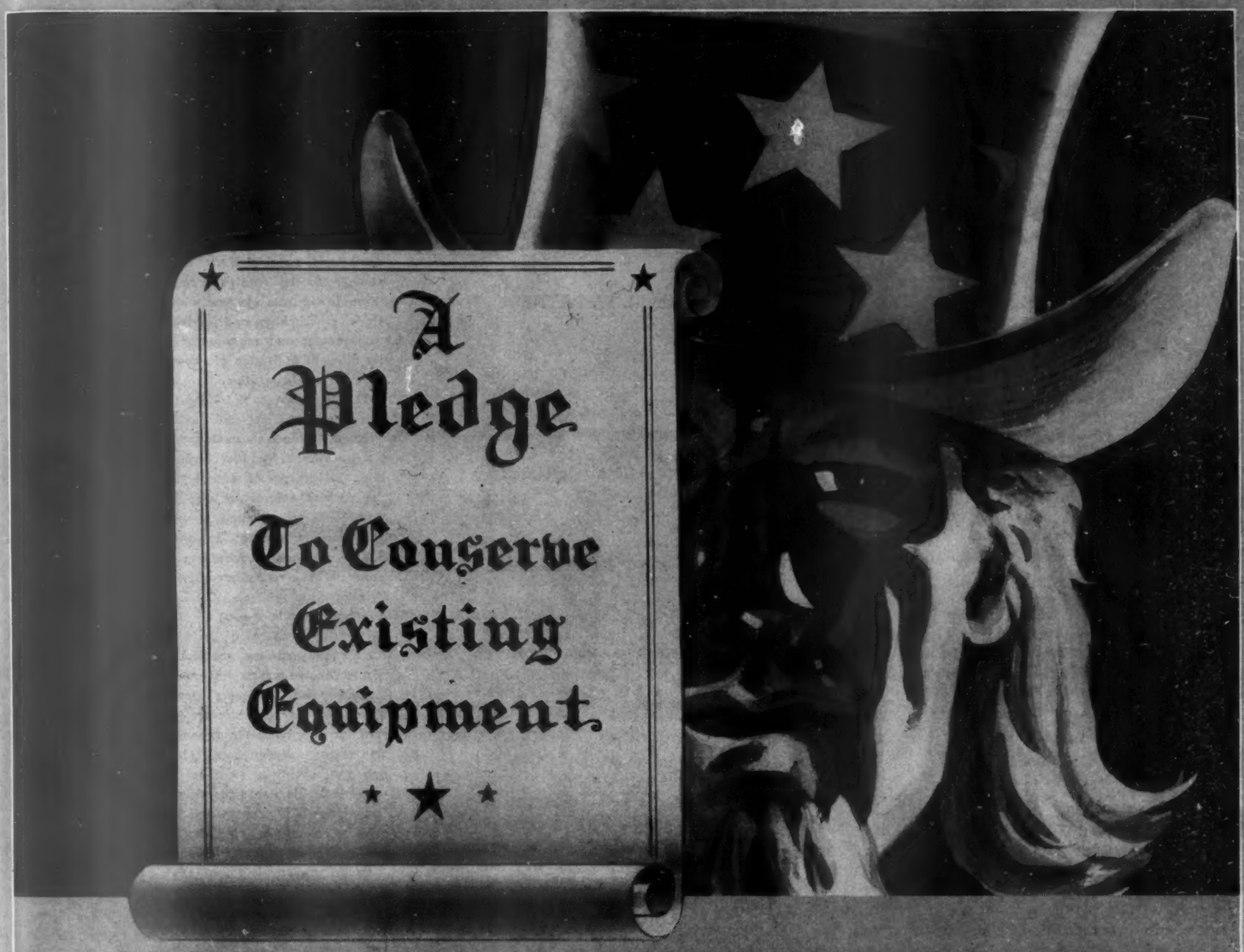
Do not store where they will be subjected to heat, or where they will be closely packed, as the coating will stick, causing rubber to come loose from fabric.

Do not use oilskins where they will be subjected to acid exposure.

Do not use this clothing where you own working clothing will answer the purpose.

It is the personal responsibility of each employe to be extremely careful when using this clothing as it is increasingly difficult to replace.

Supervisors should assume the responsibility to see that these clothes are only used when necessary.



MAKE THIS YOUR GIFT TO UNCLE SAM

HOWEVER careful we may have been in the maintenance of our equipment, patriotism and self-interest both demand we redouble our efforts for the duration . . . Iron and steel have become "precious metals," and must not be wasted through needless repairs and replacements . . . Inspect your pumps frequently . . . Look carefully to their lubrication . . . Make necessary adjustments and repairs at once . . . Gaso Pumps, having fewer and stronger parts, are naturally endowed with an abundance of economical service . . . But the life of even such equipment can be extended, and its performance maintained, through a carefully planned and rigidly followed Program of Conservation . . . Gaso Pump & Burner Mfg. Co., 902 E. First Street, Tulsa, Oklahoma. Export Office: 149 Broadway, New York. Houston: 5716 Buffalo Speedway. Los Angeles: Service Oil Field Supply Co., 5333 S. Riverside Drive.

GASO PUMPS

Fig. 1849
46 to 126 Bbls. per Hour

Fig. 1741
156 to 578 Bbls. per Hour

Fig. 2652
176 to 537 Bbls. per Hour

Thermofor Catalytic Cracking Process

By T. P. SIMPSON, L. P. EVANS, C. V. HORNBERG, and J. W. PAYNE
Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.

A. P. I.

The Thermofor catalytic cracking (TCC) process is one of the major new developments in the art of catalytic cracking. The process development has been carried through the semicommercial stage in a 500-bbl.-per-day plant to the present design of commercial units ranging in oil-charging capacity from 2,500 to 10,000 bbl. per day. The process operates on the principle of continuous catalyst flow through the reaction zone, with the catalyst circulating continuously through separate systems which form a complete cycle of cracking and revivification. The separate reactor and regenerator units are designed for efficient utilization of cheap catalysts and for flexibility of operation.

The TCC process is inherently suitable for both catalytic cracking and catalytic vapor-phase treating. Although developed, prior to the war, for cracking to produce high-octane motor gasoline, the process is equally adaptable, both in the present emergency and in the postwar period, to the production of high-octane aviation gasoline. In addition to gasoline, the process yields substantial quantities of other valuable products such as butane-butylene fraction for alkylation-plant charge, C_3 fractions, aromatics, and heating oils.

Important features of the plant design may be summarized as: low construction and operating cost, extensive use of conventional refinery equipment, low requirements of strategic materials, the use of low-pressure blowers instead of compressors for supplying the regeneration air, conversion of regeneration heat to high-pressure steam, and adaptability to small as well as large-scale refineries. This paper presents a general description of the TCC process and its relation to other existing commercial catalytic cracking processes, viz., the Houdry and Fluid catalyst processes.

Paper presented before Division of Refining at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

COMMERCIAL catalytic cracking of petroleum as practiced today is a comparatively recent development. It has only been during the last decade that this type of processing has attracted the widespread interest of the petroleum refining industry. Now due to the great importance of catalytic cracking in the producton of such important war materials as aviation gasoline, butane-butylene hydrocarbons, aromatic hydrocarbons, and butadiene, the commercial application of catalytic cracking has received an enormous impetus as a result of the war effort.

Starting about 1927 Eugene Houdry was one of the pioneers in this field and as a result of his early investigations gained strong backing by Socony-Vacuum Oil Co., Inc., and the Sun Oil Co. This group, working together through their respective research, development, and engineering organizations, attained notable success in developing catalytic cracking to the commercial stage. The first commercial Houdry catalytic cracking units were placed in operation in 1936; and since that time the Houdry[1] process has been accepted widely, and is used in the petroleum industry for producing motor fuels, aviation gasoline, and numerous allied products. The advantages of catalytic cracking were recognized quickly by the petroleum industry; and, as a result of further intensive development work, particularly during the last 5 years, new types of processes have attained commercial status in this field.

Present Commercial Processes

At the present time the major catalytic cracking processes and interests may be listed as follows:

Name—	Type	Principal development organizations	Licensors or licensing agents
Houdry	Static catalyst	Houdry, Sun Oil Co., Socony-Vacuum Oil Co., Inc.	Houdry Process Corp.; E. B. Badger & Sons Co.; The Lummus Co.; Bechtel-McCone-Parsons
Fluid	Moving catalyst	Standard Oil Co. (New Jersey) and subsidiaries; Standard Oil Co. of Indiana; M. W. Kellogg Co.; The Texas Co.; Universal Oil Products Co.; and Shell Oil Co., Inc.	M. W. Kellogg Co.; Universal Oil Products Co.
Thermofor	Moving catalyst	Socony-Vacuum Oil Co., Inc.	Houdry Process Corp.; E. B. Badger & Sons Co.; The Lummus Co.

By the end of 1943, it is estimated that these processes will have an installed charging capacity to the catalytic reactors of approximately a million barrels per day. The Thermofor catalytic cracking process—commonly referred to as the TCC process—represents one of the modern developments in this field. It is the purpose of this paper to acquaint the petroleum industry with the TCC process, describe some of its salient features, and to point out its relationship to the above-mentioned contemporary processes. However, before proceeding with a detailed discussion of the TCC process, it will be interesting to describe how Houdry, Fluid, and TCC fit into the broad technical field of catalytic cracking.

Basic Types of Catalytic Cracking

Catalytic cracking reactions may be classified broadly according to the physical state of both the catalyst and the reacting hydrocarbons in the reaction zone. The hydrocarbons may be reacted in either the vapor or liquid phase, whereas the material acting as a catalyst may be a solid, liquid, or vapor. In the present commercially important processes for catalytic cracking, viz., the Houdry, Fluid, and TCC, the hydrocarbons are substantially vaporized and cracked in the presence of solid catalysts.

Many types of catalysts have been developed for use in these three processes, but at the present time contact or adsorptive-type materials—comprising chiefly silica-alumina compositions, made by synthesis or by the chemical treating of natural clays—are used almost exclusively for this purpose. In this paper these types of materials will be assumed as the catalysts under consideration, and they may be referred to as either "synthetic" or "clay" catalysts. Catalysts of this type are used commonly in the form of granules, powders, or pellets ranging in particle size from about ⅛ in. to a few microns.

Cracking processes employing solid-type catalysts may be divided further into two basic types, according to the method of applying the catalyst:

1. Reaction systems, in which the catalyst contact mass remains static in the reaction zone and the vapors pass over the fixed catalyst bed: Houdry units exemplify this type.

2. Systems in which the catalyst moves continuously through the reaction zone: TCC and Fluid units are in this class.

Simplified flow diagrams of these types of operation are shown in Fig. 1.

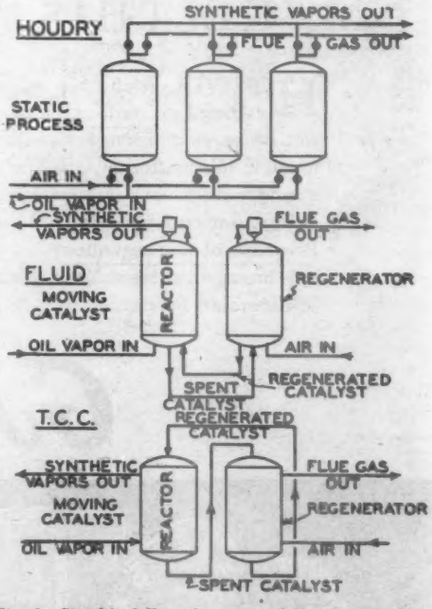


Fig. 1—Simplified flow diagrams of Houdry, Fluid, and TCC processes

Both the static and moving-bed systems are designed commercially to provide continuity in the flow of oil to the cracking plant; and in this respect the Houdry, as well as the TCC and Fluid, operations can be classed as "continuous" processes. However, technical men view the differences in the manner of handling the catalyst as the most significant distinguishing characteristic of these processes, and for this reason generally

have accepted the terminology which calls the fixed-bed type (Houdry) "static" processes, and the moving-bed type (TCC and Fluid) "continuous" processes. This terminology is used in this sense hereafter in this paper.

Common Characteristics of Present Processes

Because the TCC, Houdry, and Fluid processes employ the same fundamental type of cracking reaction they have several characteristics in common. For example, in all three types of units exposure of catalyst to oil vapors under cracking conditions fouls the catalyst with a carbonaceous deposit (commonly referred to as "coke"), which greatly reduces the catalyst activity and requires removal to restore the catalyst to its proper level of activity. This deposit is removed from the catalyst by combustion with air. On the basis of commercial units with a capacity of 10,000 bbl. per day, the amount of coke burned may vary from 20 to 120 tons per day, depending on the type of operation being conducted. Continued use of the catalyst at high temperatures causes it slowly to lose activity, and replacement of the catalyst is required either continuously or periodically. The performance of the processes is dependent, to an important extent, on the amount of catalyst used relative to oil, activity of the catalyst, soaking time, temperature, and pressure.

Having these basic features in common, the differences between TCC, Houdry, and Fluid processes lie chiefly in the physical methods employed in handling the catalyst, in contacting the oil and catalyst, and in regenerating the catalyst. Commercial units reflect the ingenuity of development engineers who have arrived at three distinct practical schemes for performing these operations, all of which are fundamentally sound.

Before proceeding with a detailed description of the TCC process a brief summary of the Houdry and Fluid operating principles is presented for comparison. In view of the fact that the product-distillation and feed-preparation equipment used in all catalytic cracking plants are of rather conventional type, the following discussion will be limited to the catalytic cracking and regeneration systems proper. It is assumed throughout this discussion that the charge to the catalytic reactor is delivered at proper temperature and pressure, and that the synthetic crude from the reactor will pass to a suitable distillation and stabilizing plant for the preparation of products and recycle stock.

Houdry—Static Units

Houdry units comprise three or more catalyst-containing vessels, called "cases," manifolded together by suitable piping and valving so that one or more of the cases may be on stream while the remainder are being regenerated. The vapors and air streams are switched from case to case by a precisely synchronized valve timing system. A complete typical cycle for a given case in a three-case unit involves 10 minutes on stream, 10 minutes valving and purging, and 10 minutes burning. By staggering the operation of the cases so that one case is always on stream, the flow of oil is maintained continuously through the system. Units having a charging capacity of 10,000 bbl. per day usually have four or more cases, whereas larger units may employ 12 cases. The catalyst in the cases remains as a fixed bed ("static"); and, as the cases alternate between burning and on-stream operations, it is necessary to provide a heat-transfer system in the cases to maintain the catalyst temperature at proper levels. This is accomplished by circulating a heat-transfer medium, usually molten salt, through finned heat-transfer tubes extending through the catalyst mass. By maintaining the heat-transfer medium at proper temperatures, normally 800° to 900° F., the catalyst is prevented from attaining heat-damaging temperatures while it is being regenerated. The catalyst is usually in the form of pills or pellets approximately 1/6 in. in diameter and length. Both clay and synthetic catalysts are employed.

Fluid—Moving-Bed Units

The Fluid process employs separate reactor and regenerator units through which the catalyst circulates continuously, undergoing alternate reaction and regeneration. The reactor operates continuously on cracking, with the oil and catalyst streams entering and leaving at fixed points. The regenerator operates as a burning unit, with air and catalyst streams likewise entering and leaving continuously at fixed points. The catalyst employed is in the form of a powder ranging in particle size from about 300-mesh down to a few microns. In the reaction system the powder catalyst is mixed intimately with oil vapor, and this mixture flows through an enlarged reaction zone. On leaving the reactor, the spent catalyst first is separated from the vapor in cyclone separators, and then transferred to the regenerator. The operation of the regenerator is similar to that of the reactor, except that the catalyst is carried by the air and flue-gas streams. Cottrell-type precipitators are employed to recover fine catalyst particles not recovered in the cyclone separators. Although details of the process have not been published, the foregoing is apparent from the patent literature.

TCC—Development

The TCC process derives its name from the Thermofor type of clay-burning kiln which is employed as the catalyst regenerating unit. The Thermofor kiln*[1] and the TCC process both

*The Thermofor kiln is licensed for regenerating petroleum decolorizing absorbents by the Max B. Miller Co., 501 Fifth Avenue, New York, under patent rights owned by Socony-Vacuum Oil Co., Inc.

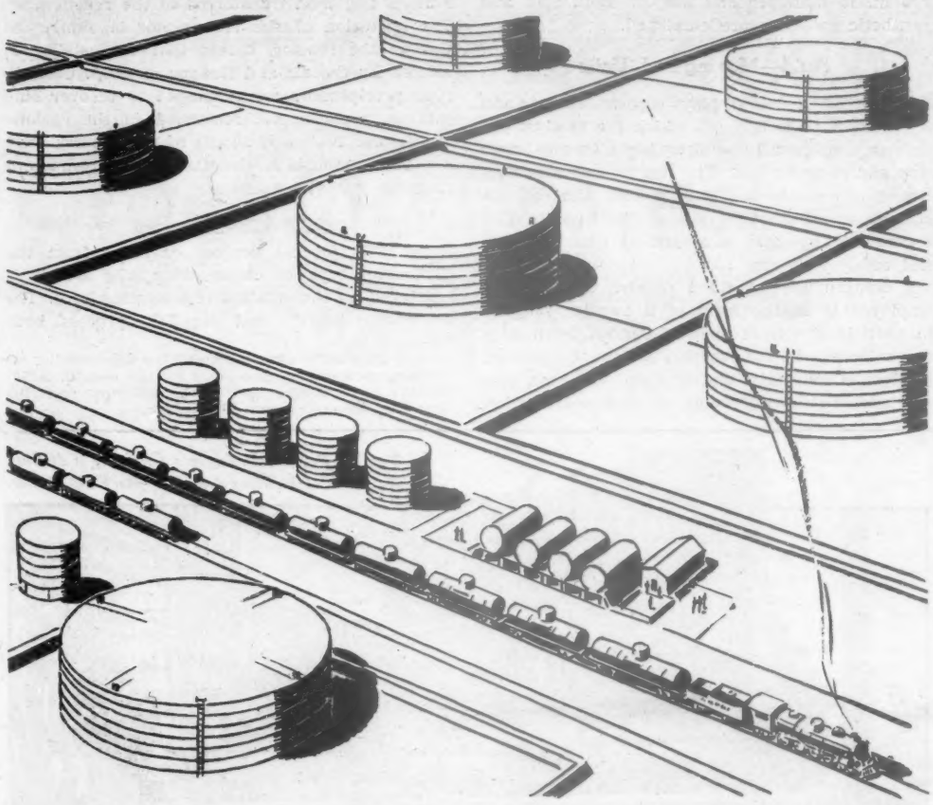
Two Le Roi RX1V Engines powering a drilling rig for R-G Drilling Co., Wichita Falls, Texas.

100,000 FEET OF HOLE
—and still going strong
— thanks to the power and flexibility
of LE ROI Drilling Engines

100,000 feet is a lot of drilling in any man's language! That's the job this rig is doing in the Hull-Silk Pool. In a period of 2½ years, over 25 wells have been drilled, each averaging about 4,000 feet in depth. And — in spite of this almost continuous service — maintenance cost on the two Le Roi power units has been less than $300. • Here's another case where careful engineering based on long experience with oil field conditions — and rugged construction to exceptional precision standards — make Le Roi power "pay out" on one tough job after another — with economical, trouble-free service. • Power *your* drilling rigs with Le Rois. Write for Bulletin DE4 giving complete information on 4-, 6-, 8-, and 12-cylinder Le Roi Drilling Engines burning gasoline, natural gas, or butane. P-13

LE ROI COMPANY • MILWAUKEE, WIS. • TULSA, OKLA.
Southern Engine & Pump Company, Houston—Dallas—Kilgore, Texas
General Machine & Supply Company, Wichita Falls—Odessa, Texas
Western Machinery Company, St. Louis, Missouri • Centralia, Illinois

Every advantage of YOUR OWN TERMINAL



General American Storage Terminals keep your bulk liquids free from contamination. These strategically located plants give you transportation savings and other outstanding advantages, too. In fact, you get every safeguard, every facility you could build into your own terminal—without spending a penny of capital! Winning the war demands elimination of waste. Learn today why so many companies rely on General American Service for economical storage.

ONLY GENERAL AMERICAN GIVES ALL THESE ADVANTAGES:

1. *RELIABLE CUSTODIANSHIP.* Our warehouse receipts are highest type of collateral everywhere.
2. *MODERN PROTECTION.* Latest safety appliances; lowest insurance rates; minimum evaporation losses.
3. *INDEPENDENT OWNERSHIP.* Strictest privacy. We do not buy, sell or refine any oils.
4. *NO WHARFAGE.* There is no wharfage charge at our own private docks.
5. *SPEED WITH SAFETY.* Day and night crews complete facilities, eliminate all shipping delays.
6. *LARGE TANK CAR FLEET.* Now working night and day, delivering essentials of war.
7. *NO CONTAMINATION.* Separate pumps, lines, storage zones for dissimilar commodities.

KEEP 'EM ROLLING! Freight cars—particularly tank cars—are vital to Victory. They must be loaded, unloaded, kept moving with all possible speed. Delays may cost lives!

GENERAL AMERICAN TANK STORAGE TERMINALS

GOODHOPE and WESTWEGO, LA. (Port of New Orleans)
CARTERET, NEW JERSEY (Port of New York)
CORPUS CHRISTI, TEXAS GALENA PARK, TEXAS (Port of Houston)

A DIVISION OF GENERAL AMERICAN TRANSPORTATION CORP.

were developed by engineers of the research and development division of Socony-Vacuum Oil Co., Inc. The first commercial installation of the Thermofor kiln for percolation clay burning was placed in operation early in 1939, and since that time five additional units have been installed and operated for that purpose. These units have given excellent performance in service as clay burners. Prior to the time the Thermofor kiln reached the commercial scale, work on continuous catalytic cracking embodying the broader principles of the TCC process already had been well advanced, and the need for an efficient catalyst regenerating unit had been appreciated fully. In view of this need, the adaptation of Thermofor kilns to TCC service offered a logical and attractive course to follow, and started the commercial development of the TCC process to a fully integrated continuous catalytic cracking operation.

The large-scale development work on TCC has been conducted in a semicommercial unit having a reactor charge capacity of 400 bbl. to 500 bbl. (42 gal.) per day. This unit has been operated for almost 2 years for a study of the variables of the process and for the development of improvements in equipment. The design of numerous commercial units now under construction is based on developments proved in this equipment supplemented by extensive fundamental laboratory studies.

TCC—Type of Catalyst

In adapting the Thermofor kiln to cracking-plant service, it was necessary to provide a catalyst having flow characteristics similar to the granular percolation clays. Catalysts of this type have been developed successfully in the form of granular masses consisting predominantly of particles varying in coarseness from about 4 to 60-mesh size. In this form, the catalyst mass flows freely through properly designed equipment. Catalysts may be formed to the proper particle size by the pelleting or extruding of powdered materials, or by the crushing of large lumps.

Satisfactory catalysts must possess proper catalytic activity and at the same time be sufficiently rugged to resist mechanical breakdown in the cracking plant. The useful life of a catalyst in service is governed both by its physical strength and its catalytic stability. At present commercial catalysts used in the TCC process are prepared from especially treated natural clays which are cheap, costing only a few cents per pound, and available in large quantities. Attrition rates for these catalysts in commercial TCC units will be less than 1 lb. of catalyst per barrel of total oil charge to the reactor. Other catalysts of the synthetic or semisynthetic type show considerable promise for future use.

Flow in TCC Units

Referring to the simplified TCC flow diagrams (Fig. 2), it will be noted that the catalytic part of a TCC plant comprises separate reactor and regenerating systems through which the catalyst is circulated continuously. In this respect the TCC and Fluid processes may be regarded as similar; but the similarity ends here, because the two processes differ widely in principle of operation. This will be apparent from the following detailed description of flow in a TCC plant.

Starting with the catalyst hopper (Fig. 2) located directly above the reactor, the clay flows downward by gravity through an elongated clay feed pipe, which supplies catalyst to a distributing hopper immediately above the reaction zone. Catalyst flows from this distributing hopper through several distributing pipes to the top of the main catalyst bed in the reactor. From this point the catalyst gravitates downward through the reactor countercurrent to the oil vapors, which enter at the bottom of the reaction zone. The reaction zone contains iron baffles designed

FOR *Surplus* SPEED *and* SAFETY

USE WARREN'S STABILIZED NATURAL GASOLINE

To raise the octane rating and fire power of your wartime motor fuel and lower your refining costs, use Warren's Stabilized Natural Gasoline. Because of its plus elements of speed, power and performance, Warren Natural Gasoline insures a superior product of uniform quality. It's today's best buy in the petroleum industry. Warren is a good source of supply.

WARREN PETROLEUM CORPORATION

Manufacturers, Exporters and Marketers of Natural Gasoline and Liquefied Petroleum Gas

Tulsa, Oklahoma

Export Terminals: Corpus Christi, Port Arthur and Norsworthy, Houston, Texas, Lake Charles, La., and Marcus Hook, Pa.

to provide intimate contact between the vapors and catalyst, without interference with the uniform flow of the catalyst. At the top of the reaction bed, vapors are released from the catalyst mass, in which mass are contained several flues which collect the vapors from the reaction zone proper and conduct them through the top part of the catalyst bed into the open space immediately above. Below the oil inlet there is a purge zone, likewise containing baffles, in which the spent catalyst leaving the reaction zone is purged of oil vapors by means of superheated steam. After having been purged with steam in the bottom of the reactor, the spent but purged catalyst is released through a valve and flows into a conveyor, where it is carried to the supply hopper of the Thermofor-type kiln used for regenerating the spent catalyst.

From the kiln supply hopper, the spent catalyst flows through distributor pipes to the top of the catalyst bed in the kiln burning zone. It then passes downward by gravity flow through the burning zone of the kiln countercurrent to the air supplied for burning. In this zone the carbonaceous deposit is removed from the catalyst by combustion with air. A number of special types of TCC kilns have been developed for catalyst regeneration, but for practical purposes the spiral-finned type of Thermofor kiln[2] may be considered as representative. With this type, the main burning zone of the kiln is filled with a bundle of spiral-finned tubes. These tubes are designed to provide air passages up under the spiral fins, while catalyst moves slowly downward over and around the fins. Molten salt, steam, or other heat-transfer mediums may be circulated through the finned tubes to control burning, and to prevent the catalyst from attaining heat-damaging temperatures. The fins provide both air passages and heat-transfer surface. Air required for burning is supplied near the bottom of the finned tubes. Combustion gases are released from the catalyst mass by means of flues, which flues pass through the clay bed immediately above the heat-transfer system. Regenerated catalyst leaving the bottom of the kiln passes through a valve, and is picked up by a second conveyor which discharges it into the catalyst hopper above the reactor, thus completing the circuit. Catalyst flow rates through the reactor and kiln are controlled by adjusting the valves on the lines discharging catalyst from the bottom of these reactor and kiln units to the conveyors. It will be noted that regeneration of the catalyst is controlled without the recycling of flue gas or catalyst in the regeneration system.

The range of operating conditions for reactor and kiln in the TCC process is as follows:

Reactor	
Temperature in reaction zone, °F.	750 to 950
Reactor pressure, p.s.i.	10 to 15
Space velocity*	0.2 to 3.0
Ratio of catalyst to oil†	1.0 to 8.0
Steam, per cent by weight of oil charge	0 to 20
Regenerator	
Regenerator temperature, °F.	700 to 1,100
Operating pressure	Atmospheric
Air consumption, standard cubic feet per ton of catalyst circulated	2,000 to 20,000
Temeprature of air supply, °F.	Atmospheric to 1,000

*Space velocity is calculated as the ratio of volume of liquid oil charge per hour to apparent volume of catalyst mass in reaction zone.

†Ratio of apparent volume of catalyst circulated to liquid volume of oil charged per unit of time.

It will be noted that the TCC process requires only moderate temperatures and pressures, which may be attributed largely to the efficient method of reacting and revivifying the catalyst. This has been translated into a plant design that is both economical and flexible. Thus, plant construction is inexpensive, involving chiefly carbon steel and conventional refinery equipment. The process requires no compressors, the combustion air to the kiln being supplied by a low-pressure blower. The kiln itself has a variable regeneration capacity, permitting a wide choice of cracking conditions and charging stocks; and also is designed

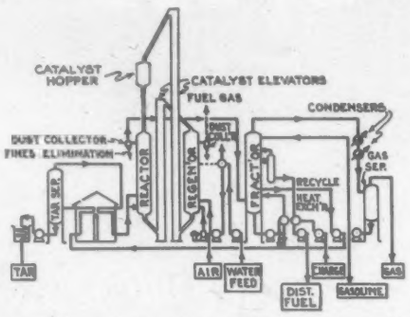


Fig. 2—Flow diagram of Thermofor catalytic cracking process

to convert the excess heat obtained from catalyst regeneration into high-pressure steam. Finally, plants can be designed in smaller sizes without serious sacrifice in economy, thus making the process attractive to small as well as large-scale operators. At present TCC units have been designed in sizes of 2,500 bbl., 5,000 bbl. and 10,000 bbl. of charge per day to the reactor, but intermediate sizes may be designed to meet any requirement.

The high degree of flexibility of the TCC process is demonstrated by the fact that the process is equally adaptable to the production of motor gasoline and high-octane aviation gasoline.

Due to the restrictions imposed by war conditions, it is not possible to publish herein detailed data regarding the performance of the TCC process. Considerable data have been developed concerning the production of motor and aviation gasolines, which data show that the TCC process gives yields and products comparing favorably with those from other catalytic cracking processes employing similar catalysts. Although these results cannot be published for general use, they are available to potential licensees through the licensing agents for the process. However, the following discussion will give a general idea as to the type of results obtained from the process.

TABLE 1—TYPICAL YIELDS OBTAINED BY TCC CRACKING OF MID-CONTINENT GAS OIL FOR MOTOR GASOLINE

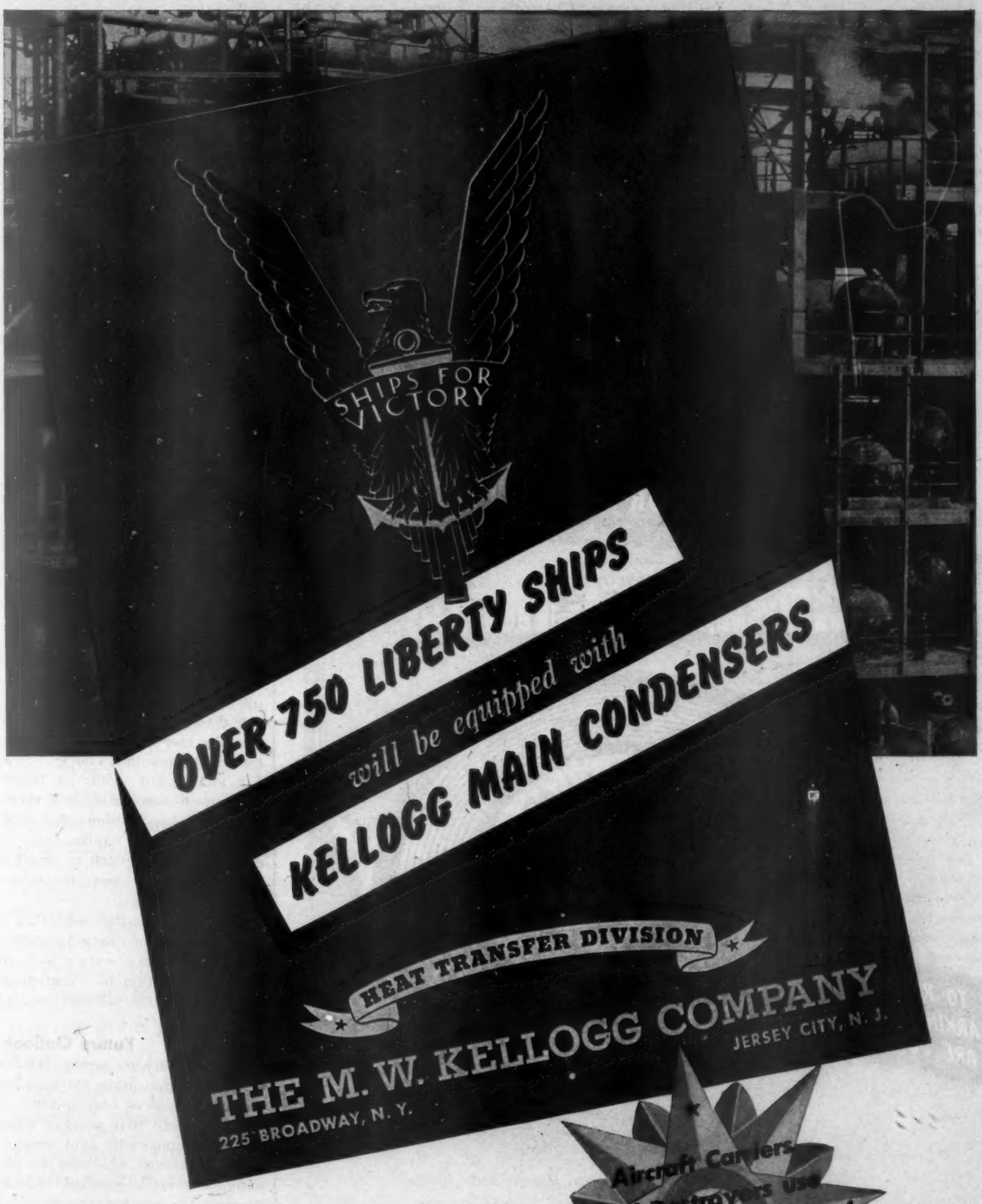
	Case "A" Single-pass operation	Case "B" 1-to-1 recycle operation
Temperature, °F.	850	860
Pressure, p.s.i., gage	10	10
Yields on fresh feed (per cent by volume):		
Motor gasoline, C_5-free	39	56
Catalytic gas oil	48	26
n-Butane	3	2
Isobutane	4	5
n-Butylenes	5	6
Isobutylene	1	2
Total liquid products	100	97
Fuel gas, C_3 plus lighter (per cent by weight)	5	9

Motor-Gasoline Production

Motor gasoline is produced by the cracking of distillate stocks, either once-through or with recycling. Within the range of variables outlined previously, once-through operations give motor-gasoline yields of 35 to 62 volume per cent on gas-oil charging stocks. Similarly, operations employing recycling of catalytic gas oils give motor-gasoline yields of 50 to 85 per cent. Motor-gasoline yields of 35 to 45 per cent single-pass, and of 50 to 60 per cent with recycling, are representative of commercial proposals. Recycling op-

TABLE 2—PROPERTIES OF TYPICAL MOTOR GASOLINES FROM TCC CRACKING ON CLAY CATALYST

Source of gasoline—	Paraffinic gas oil	Mixed-base gas oil	Naphthenic gas oil
Gravity, °A.P.I.	60.6	60.0	52.7
Reid vapor pressure, lb.	9.6	9.7	9.5
Doctor test	Negative	Negative	Negative
Mercaptan test	Negative	Negative	Negative
Copper-dish gum, mg.	16	27	10
Glass-dish gum, mg.	1	2	2
Oxygen-bomb test, hours and minutes	12:30	20:30	8:30
Color, Saybolt	+16	+10	+15
Octane No.			
C.F.R. motor method (without TEL addition)	76.9	78.1	82.0
C.F.R. road method:			
Without addition of TEL	84.1	87.4	92.0
With addition of 1 ml. TEL per gal.	91.9	93.1	96.5
With addition of 2 ml. TEL per gal.	93.7	94.8	98.2
With addition of 3 ml. TEL per gal.	95.1	96.0	99.2
A.S.T.M. distillation (°F.)			
Initial boiling point	90	89	88
5 per cent point	110	106	110
10 per cent point	121	119	125
20 per cent point	145	140	156
30 per cent point	175	170	198
40 per cent point	209	206	237
50 per cent point	243	240	267
60 per cent point	276	268	294
70 per cent point	307	307	322
80 per cent point	337	332	346
90 per cent point	376	365	369
End point	404	398	410
Recovery per cent	97.5	97.0	97.5
Loss, per cent	1.5	2.0	1.3


SHIPS FOR VICTORY
OVER 750 LIBERTY SHIPS
will be equipped with
KELLOGG MAIN CONDENSERS
HEAT TRANSFER DIVISION
THE M. W. KELLOGG COMPANY
JERSEY CITY, N. J.
225 BROADWAY, N. Y.
Aircraft Carriers and Destroyers use KELLOGG prefabricated high Pressure Piping

KELLOGG THE M. W. KELLOGG COMPANY
JERSEY CITY, N. J. · 225 BROADWAY, N. Y.
Representatives:
LOS ANGELES: 809 SOUTH GRAND · TULSA: PHILTOWER BLDG.

"Masterflex" Prefabricated Piping Systems · "Masterweld" pressure vessels for Power, Refinery and Chemical Industries. Heat Exchangers. Pyrolytic and Catalytic Cracking Units, Reforming, Dehydrogenation, Alkylation, Desulphurization. Thermal and Catalytic Polymerization Units · JUIK Processes for Lubricating Oil Plants. Plastic Refractories · Radial Brick Chimneys.

erations are preferable, from the standpoint of ultimate yield, as the first step in the production of aviation gasolines. Typical single-pass and recycle cracking operations on gas oil are exemplified by cases "A" and "B" in Table 1. Properties of typical motor gasolines obtained from various stocks are shown in Table 2.

Aviation-Gasoline Production

Aviation gasoline of excellent quality is produced by the reprocessing of the first-pass motor gasoline in a TCC reactor operated on a once-through basis, at somewhat lower throughput rates than in cracking. This second-pass operation, which yields 80 to 95 per cent of the aviation cut present in the motor-gasoline charge, serves primarily to improve the leaded octane numbers, oxidation stability, gum stability, and aromatic content of the aviation fraction. A few general data on quality of two-pass TCC aviation gasolines are shown in Table 3.

Other Products

The two-pass operations described previously herein will yield, in addition to gasoline, a butylene fraction as high as 8 per cent by volume of the gas oil. This can be increased considerably by cracking at elevated temperatures, without undue sacrifice in gasoline yield.

The yield of butanes, of which more than half represents isobutane, is generally of the order of 5 to 8 per cent, and is not increased by severe cracking.

The potential yield of alkylate from the butylenes available in the total butane-butylene fraction from a two-pass TCC operation for aviation gasoline will supply a substantial portion of the total alkylate requirement for the blending of aviation gasoline to 100-octane number. In addition, the two-pass operation yields an excess of isopentane concentrate over that required to pressure the total 100-octane-number blend of alkylate and base stock to 7 lb. Reid vapor pressure.

Other valuable byproducts available in substantial quantity from TCC operations include: aromatic hydrocarbons such as benzene, toluene, and xylenes; naphtha fractions of high aromaticity and high octane rating; olefin-rich fuel gas, of which 35 to 40 per cent by weight represents chiefly propylene plus some ethylene; and catalytic gas oil, of which from 60 to 100 per cent will meet No. 2 specifications, depending on the end point of the gas-oil charging stock.

TABLE 3—APPROXIMATE RANGE OF QUALITY OF 7-LB. R.V.P.* AVIATION GASOLINES OBTAINED BY TWO-PASS TCC PROCESSING WITH CLAY CATALYST

Acid heat, °F.	10 to 25
Accelerated-gum test (5-hour), mg. per 100 ml.	3 to 5
Aromatic content, per cent by volume	20 to 30
Octane No. (AFD-1C)†	
Without TEL addition	77 to 80
With addition 3 ml. TEL per gal.	92 to 95
With addition 4 ml. TEL per gal.	94 to 97
100-octane-number alkylate blend‡ plus 4 ml. TEL per gal., per cent by volume of alkylate	22 to 45

*Reid vapor pressure.
†AFD-1C = λ
‡This gasoline has the necessary combustion characteristics to permit it to comply with latest aviation-gasoline specifications.

Summary

From the standpoint of the national emergency, the features of the TCC process may be summed up as follows:

1. Good yields of 100-octane-number aviation-gasoline blending stocks and butane-butylene out for alkylation-plant charge.
2. Substantial yields of byproducts, including heating oils, aromatics, and propylene.
3. Low construction cost and adaptability to existing refinery equipment, bringing catalytic cracking within reach of small refiners.
4. Low requirements for alloy steels and other strategic materials.
5. Flexibility with respect to type of operation and character of charging stock.
6. Conversion of excess heat obtained from catalyst regeneration into high-pressure steam.
7. Adaptability to wartime and peactime production basis.

Future Outlook

In the postwar period the TCC process will find wide application for manufacturing catalytic motor gasoline of high quality. There appears to be little doubt that postwar gasoline manufacturing operations will find catalytic cracking displacing thermal cracking to an ever-increasing extent. Aviation-gasoline manufacture and the demand for greater quantities of butylene probably will continue at a rate intermediate between the prewar and wartime requirements. The TCC operation will meet these requirements in excellent fashion because of its broad range of flexibility. Likewise, with emphasis being placed on low operating and investment costs, the TCC process will maintain a strong position because of its outstanding characteristics in these respects.

References

1. Houdry, Burt, Pew, and Peters, "Catalytic Processing of Petroleum Hydrocarbons by the Houdry Process," Proc. A.P.I. 19 (3) 133 (1938).
2. Simpson and Payne, "New Thermofor Kiln and Clay-Regeneration Processes for Maintaining Decolorizing Clays at High Efficiencies," Proc. A.P.I. 20 (3) 7 (1939).
3. Simpson, Nicholls, and Payne, Trans. Am. Inst. Chem. Engrs. 36 (6) 841 (1940).

LUFKIN "ANCHOR"
CHROME CLAD STEEL TAPES WITH
½ INCH LINE FOR HEAVY DUTY
INCH
LUFKIN
CHROME CLAD
STEEL
TAPE
THE LUFKIN RULE CO
EASY TO READ
MARKINGS
THAT ARE DURABLE
needs a sturdy tape, then
with the half inch line. The satin
chrome surface won't rust, crack, chip or peel. Jet black markings are
easy to read even in poor light. The genuine leather hand-stitched
case is durable and easy to handle. Folding flush handle is opened
by a push pin. A dependable, well-built tape from every standpoint.
THE LUFKIN RULE CO.
TAPES · RULES · PRECISION TOOLS
SAGINAW, MICHIGAN
NEW YORK CITY

BUSY MENS' TIME *Is Saved by Fully-Automatic Micromax Pyrometers*

For days at a time, Micromax Pyrometers and Pneumatic Controllers can operate without the help of a human hand. They do this, in countless refineries, because they have, inside themselves, automatic "hands" which attend to routine needs, or are raised to call attention when the instrument man is needed.

Probably most important of these "hands" is the automatic standardizer. It operates every 45 minutes—much oftener than a man would standardize the instrument; oftener even than is necessary if the equipment's operating cells are at their best level of performance. But very new cells, or very old ones, or ones which have been damaged, may not be at a good level. So, Micromax takes no chances. It standardizes every cell so frequently that any one gives good service until exhausted.

And, as a cell approaches exhaustion, a "hand" raises a signal, calling for attention. Similarly, advance warning is given when fresh chart will be needed; or more ink. Even the failure of electric power can be noted.

Micromax Pyrometers and Pneumatic Controllers are made in ranges and models for all the more important temperature-handling requirements of a refinery. For general information, ask for Catalogs; if you have a specific problem, kindly outline it.

LEEDS & NORTHRUP COMPANY, 4959 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Jrl Ad N-33A-702(55)

Method for Analyzing Gasoline Fraction of Petroleum with Preliminary Results on East Texas and Oklahoma Crudes

By FREDERICK D. ROSSINI,* BEVERIDGE J. MAIR,† ALPHONSE F. FORZIATI,‡ AUGUSTUS R. GLASGOW, JR.,‡ and CHARLES B. WILLINGHAM‡

FOR about 15 years A.P.I. Research Project 6 has been exhaustively separating one crude petroleum by distillation, extraction, adsorption, and crystallization, and to date has separated a total of 69 hydrocarbons from the gas, gasoline, and kerosene fractions, together with a large number of "homogeneous" fractions from the lubricant portion.[1,2] The knowledge of the hydrocarbons in petroleum obtained in this comprehensive investigation is providing a basis or framework by means of which less extensive and more rapid analyses of other crude petroleums can be made to yield, with regard to the hydrocarbon constituents, information which otherwise would not be obtainable.

In 1941 the advisory committee§ for A.P.I. Research Project 6 recommended that a survey be started by the project on the analysis of the gasoline fraction of representative crude petroleums from various fields. All of the experience and knowledge gained in the comprehensive investigation on the one crude petroleum was to be brought to bear on this new problem in order to bring forth in a relatively short time fruitful information on the hydrocarbons in the gasoline fraction of the selected petroleums. Within the past year the project has developed a method of analysis for this work which it is hoped will have application beyond the bounds of the present investigation. This paper briefly describes the method, and gives some preliminary results on East Texas and Oklahoma crudes.

A. P. I.

This paper gives a general description of a method for analyzing the gasoline fraction of petroleum with respect to the main hydrocarbon components. The results of a test experiment on a mixture of 17 known hydrocarbons (six paraffins, four naphthenes or cycloparaffins, and seven aromatics) normally boiling in the range from 60° to 174° C., are presented, together with preliminary results on the naphtha fractions from East Texas and Oklahoma crude petroleums.

Paper presented before Division of Refining at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

General Description of the Method

The method consists essentially in applying the fractionating processes of adsorption and distillation to the naphtha fraction. The process of adsorption is used to separate from the naphtha fraction a portion containing the aromatic hydrocarbons and a portion containing the paraffins and naphthenes. Then the process of distillation is used to resolve each of these two portions separately.

By adsorption, the naphtha is first separated into two portions: one containing the aromatic hydrocarbons, together with the nonhydrocarbon components; and the other, the paraffins and naphthenes. From the first portion, the small amount of nonhydrocarbon components (principally sulfur compounds) are separated by further adsorption to give a clean aromatic portion. Then the clean aromatic portion and the paraffin-naphthene portion separately are subjected to an analytical distillation at a high reflux ratio in a column of high efficiency and low holdup. The boiling point of the distillate is observed as a function of its volume. The distillate is collected in fractions as small as practicable and the refractive index of each fraction is determined. When necessary for further identification, the density is determined (by combining two or more adjacent fractions, if necessary).

The determination of the main hydrocarbon components in the respective aromatic and paraffin-naphthene portions is based upon a comparison of the boiling point, refractive index and, when necessary, the density of the fractions of distillate with those of appropriate pure compounds.

It is important to note that the distillation of the aromatic hydrocarbons separately from the paraffins and naphthenes, as outlined hereinbefore, not only makes much easier the determination of the main aromatic compounds, but also immensely improves the resolution of the main components in the paraffin-naphthene portion. This improvement results partly from the reduction in the number of compounds in the mixture being distilled, but mainly from the fact that the relations of vapor pressure and temperature are much more homogeneous for the aromatic portion and for the paraffin-naphthene portion separately than for the original mixture of the two portions.

The separation of the naphtha into an aromatic portion and a paraffin-naphthene portion by the process of adsorption requires only 1 or 2 days, depending upon the amount of aromatics to be separated. On the other hand, the analytical distillation of the two separated portions may be made to require as little as 2 or 3 days, or as much as 2 or 3 months, depending on the extent to which the resolution by distillation is to be carried; i.e., the time required for the analysis of naphthas by this method will vary from about 1 week per naphtha for a routine method wherein it is desired to obtain sufficient information for the intelligent immediate utilization of the material in plant processing, to 2 or 3 months per naphtha for a research method wherein it is desired to learn as much as possible about the individual components of the material from the standpoint of long-range planning for its utilization.

Procedure of the Present Investigation

In the present investigation the amount of the naphtha selected for processing is such as to produce not less than about 600 ml. of an aromatic portion and not less than about 3,600 ml. of a paraffin-naphthene portion. Then each of these two portions in the amounts stated is subjected to an efficient analytical distillation. The distillate is collected in fractions of 6 ml., each representing about 1/100 of the aromatic portion and about 1/600 of the paraffin-naphthene portion. For each fraction, determination is made of the refractive index, N_D. When necessary for further identification, two consecutive fractions are combined for measurement of the density, by means of a specific-gravity balance which requires a minimum volume of 10 ml. and which has a precision of ± 0.00003 g. per ml.

The process for adsorption used in the present investigation to separate and recover the aromatic hydrocarbons from the paraffins and naphthenes is an improved modification of that described in earlier papers of the project.[3,3] The new procedure is given in detail in a recently completed report[4] of the project which, during the war period, is available for restricted distribution to the American Petroleum Institute and U. S. government laboratories and, on application, to other appropriate groups. As mentioned in the preceding section, the small amount of sulfur and other nonhydrocarbon compounds, which in the first adsorption are separated with the aromatic hydrocarbons, then are removed (together with a small amount of aromatic hydrocarbons) from the "aromatic" portion by further adsorption to produce a clean aromatic portion for distillation.

The analytical distillations of the aromatic and the paraffin-naphthene portions obtained in the present investigation are being performed in the two columns whose operating characteristics are given in Table 1. Still "O" is being used on the aromatic portion and still "P" on the paraffin-naphthene portion. The assembly, testing, and operation of these rectifying columns will be described in a separate publication.[5] As can be seen from the data given in Table 1, the time

*National Bureau of Standards, Washington, D. C.; director A.P.I. Research Project 6.
†Senior research associate, A.P.I. Research Project 6, at the National Bureau of Standards.
‡Research fellow A.P.I. Research Project 6, at the National Bureau of Standards.
§J. Bennett Hill, Sun Oil Co., chairman; William J. Sweeney, Standard Oil Development Co.; Seymour W. Ferris, Atlantic Refining Co.

Again Schlumberger is First With a New Service

SCHLUMBERGER DIPMETER

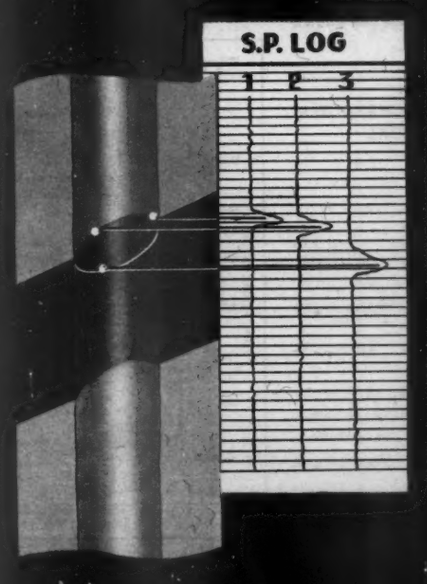
Reveals

THE DIRECTION AND MAGNITUDE OF FORMATION DIP

Schlumberger Dipmeter Surveys employ two proven Schlumberger services in combination—electrical well logging and photoelectric directional surveys. On a single trip in the hole, both direction and magnitude of dip can be accurately determined. The instruments are operated on the standard Schlumberger cable and winch and the survey time is approximately the same as that required for electrical logging.

Complete details will gladly be sent interested operators on request.

SCHLUMBERGER WELL SURVEYING CORP.
HOUSTON, TEXAS



required for the distillation of the aromatic portion is nearly 1 month, with continuous operation 24 hours per day, 7 days per week; and the time required for the distillation of the paraffin-naphthene portion is more than 2 months with similar continuous operation. By such distillation it is possible to separate effectively a considerable number of individual components in one distillation.

In the distillation of the aromatic portion (see Fig. 5, for example) each of the eight possible aromatic compounds normally boiling below 160° C. can be resolved with the exception of *p*-xylene and *m*-xylene, which normally boil only 0.8° C. apart near 139° C. Fortunately, however, the composition of the mixture of *p*-xylene and *m*-xylene can be determined readily from a measurement of its freezing point. Above 160° C., the number of possible aromatic compounds increases rapidly, and the extent of the analysis which is possible will depend upon the number of close-boiling neighbors, and upon the difference in their refractive indices and densities.

In the distillation of the paraffin-naphthene portion (see Fig. 4, for example) it is likewise possible to resolve a number of individual components in the one distillation. Excluding *cis*-1,2-dimethylcyclopentane near 99° C., *cis*-1,3-dimethylcyclopentane near the same temperature, 2,2,3-trimethylbutane at 80.9° C., and 2,2,4-trimethylpentane at 99.2° C.—no one of which has yet been found in any petroleum*—there are 20 possible paraffin and naphthene (cyclopentane and cyclohexane derivatives) hydrocarbons normally boiling in the range from 40° to 102° C. These are as follows:

Compound—	Type	Boiling point (°C.)	
Cyclopentane	Naphthene	49.5	B
2,2-Dimethylbutane	Paraffin	49.8	
2,3-Dimethylbutane	Paraffin	58.0	A
2-Methylpentane	Paraffin	60.3	A
3-Methylpentane	Paraffin	63.3	A
n-Hexane	Paraffin	68.7	A
Methylcyclopentane	Naphthene	71.9	A
2,2-Dimethylpentane	Paraffin	79.0	A
2,4-Dimethylpentane	Paraffin	80.8	B
Cyclohexane	Naphthene	80.8	
3,3-Dimethylpentane	Paraffin	86.0	A
1,1-Dimethylcyclopentane	Naphthene	87.5	A
2,3-Dimethylpentane	Paraffin	89.8	
2-Methylhexane	Paraffin	90.0	
trans-1,3-Dimethylcyclopentane	Naphthene	90.9	C
trans-1,2-Dimethylcyclopentane	Naphthene	91.9	
3-Methylhexane	Paraffin	92.0	
3-Ethylpentane	Paraffin	93.5	A
n-Heptane	Paraffin	98.4	A
Methylcyclohexane	Naphthene	100.9	A

A distillation column having a separating efficiency near 120 theoretical plates can effect a separation of two hydrocarbons normally boiling as little as 1.5° C. apart. One distillation in such a column of a mixture containing all of the foregoing 20 components would yield the following results: the 11 compounds marked "A" would be substantially separated as individual components; the two pairs marked "B" would be binary mixtures each containing a paraffin and a naphthene hydrocarbon of about the same boiling point, the relative amounts of which could be determined readily from the refractive index or density or both; the mixture of five hydrocarbons marked "C" would not be resolvable in the one distillation, but the relative amounts of paraffins and naphthenes could be determined readily from the refractive index and density. It is interesting to note that all of the 20 hydrocarbons listed previously herein have been isolated from petroleum[1,2,3] with the exception of the following four compounds: 2,4-dimethylpentane at 80.8° C.; 3,3-dimethylpentane at 86.0° C.; 2,3-dimethylpentane at 89.8° C.; and 3-ethylpentane at 93.5° C.

*It is likely that every petroleum contains at least a minute amount of nearly every possible paraffin, naphthene, or aromatic hydrocarbon. Fortunately, however, the bulk of the gasoline fraction of Mid-Continent petroleum, and to a greater or lesser extent other crudes, is made up of a relatively small number of compounds.[1] If found in petroleum in any significant amount, the two *cis*-dimethylcyclopentanes mentioned previously likely would appear in a naphtha very rich in naphthenes, and the two trimethyl paraffins in a naphtha very rich in isoparaffins.

Test of the Method With a Mixture of Known Hydrocarbons

In order to establish the reliability of this method of analysis, and to learn something of the amount of loss of material in processing, a test mixture of 17 known hydrocarbons, normally boiling in the range from 60° to 174° C., was prepared quantitatively by weight. The mixture had a volume of about 2.3 l., and consisted of six paraffin, four naphthene, and seven aromatic hydrocarbons.

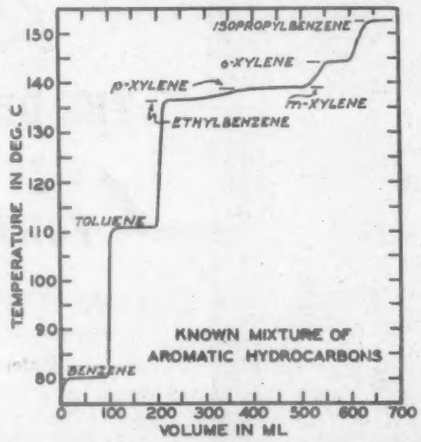


Fig. 1—Plot of the boiling point as a function of volume for the distillation (at a controlled pressure of 770 mm. mercury) of the aromatic hydrocarbons from the known test mixture

TABLE 1—APPROXIMATE OPERATING CHARACTERISTICS OF THE TWO ANALYTICAL DISTILLATION COLUMNS

Designation of still	"O"	"P"
Rectifying section:		
Diameter, mm.	10	13
Length, mm.	1,830	1,830
Packing	Steadman	Heli-Grid
Operating throughout (liquid), ml. per hour	About 150	About 250
Operating holdup (liquid), ml.	About 25	About 30
Operating pressure drop, mm. of mercury	18	10
Reflux ratio	120 to 1 150 to 1	120 to 1 150 to 1
Rate of removal of distillate (liquid), ml. per hour	1	2 to 2½
Nature of charge	Aromatic	Paraffin-naphthene
Volume of charge, ml.	600	3,600
Time of distillation, hours	600	1,600
Pressure, mm. of mercury	770	770

This mixture was separated by the process of adsorption into two lots: one containing the aromatic hydrocarbons, and the other containing the paraffins and naphthenes. Each lot then was subjected to an analytical distillation. An indication of the completeness of the separation, and of the amount of material lost during the process of adsorption and distillation, is given by the summary:

Material—	Aromatics	Paraffins+ naphthenes	Total
Charged	624.91 g.	1,126.01 g.	1,750.92 g.
	35.69 per cent	64.31 per cent	100.00 per cent
Recovered	617.71 g.	1,099.66 g.	1,717.37 g.
	35.28 per cent	62.80 per cent	98.08 per cent
Loss	7.20 g.	26.35 g.	33.55. g.
	0.41 per cent	1.51 per cent	1.92 per cent

If the amounts of aromatics and of paraffins plus naphthenes lost in the two fractionating processes are approximately in the same ratio as their percentages in the original mixture, the composition of the material recovered will be, on a parcentage basis, the same as that of the material charged. The extent to which this was true in the foregoing experiment is indicated by the following figures giving percentages by weight:

Material—	Aromatics (per cent by weight)	Paraffins+ naphthenes (Per cent by weight)	Total (per cent by weight)
Original	35.69	64.31	100.00
Product	35.97	64.03	100.00
Difference	+0.28	—0.28	

Because the distilling columns described in Table 1 had not yet been assembled, the two portions of the test mixture were distilled separately in a column, with the following operating characteristics: rectifying section, 15 mm. in diameter and 2,800 mm. in length; operating throughput, 750 ml. of liquid per hour; separating efficiency at the operating throughput, near 110 theoretical plates; operating holdup, about 75 ml. of liquid; reflux ratio, 120. The values of boiling point and refractive index of the distillate, as a function of its volume and mass, showed in the case of both portions excellent accord with the known compositions of the material.

Fig. 1 gives a plot of the volume-temperature relation for the distillation of the aromatic portion. Fig. 2 gives a similar plot for the paraffin-

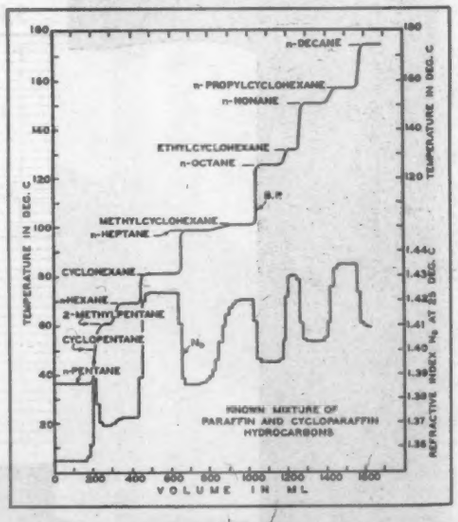


Fig. 2—Plot of the boiling point and refractive index as a function of volume for the distillation (at a controlled pressure of 770 mm. mercury) of the paraffin and naphthene hydrocarbons from the known test mixture

naphthene portion, together with a plot of the refractive index as a function of the volume of distillate. The appropriate compounds are indicated on the charts. Table 2 compares the known composition of the material charged into the adsorption process with the analysis of the product from the distillation process.

Preliminary Results on East Texas Naphthas

The East Texas naphtha was provided by the Standard Oil Development Co. Batch-distillation data on the crude petroleum were reported by them as follows:

	Percentage of crude (by volume)	Aniline point (°F.)	Gravity (°A.P.I.)
C_4 fraction	0 to 1.0	...	...
C_5 fraction	1.0 to 3.3	...	...
Light naphtha	3.3 to 14.3	128	66.6
Heavy naphtha	14.3 to 38.8	126	50.8

Data on the Engler distillation for the light and heavy naphtha are given in Table 3. For this investigation, the "depentanized" light naphtha and the heavy naphtha were combined in the production proportion of 11.0 to 24.5, by volume, to make the total East Texas naphtha for analysis. The material examined represented 35 per cent by volume of the crude petroleum. By a method developed recently in the work of A.P.I. Research Project 6 the amount of aromatic hydrocarbons in this East Texas naphtha were found to be 10.1 per cent by volume. The sulfur content of the naphtha was 0.033 per cent by weight, as determined under the supervision of R. C. Hardy in the Section on Lubrication and Liquid Fuels at the National Bureau of Standards.

TABLE 2—ANALYTICAL DATA ON THE TEST MIXTURE OF 17 KNOWN HYDROCARBONS BEFORE AND AFTER PROCESSING

Compound—	Boiling point (°C.)	Percentage by weight of charge	Percentage by weight of product	Difference (per cent)
2-Methylpentane	60.3	3.30	3.58	+0.28
n-Hexane	68.7	5.56	5.10	−0.46
Benzene	80.1	4.94	5.10	+0.16
Cyclohexane	80.8	9.08	8.86	−0.22
n-Heptane	98.4	7.59	7.82	+0.23
Methylcyclohexane	100.9	8.08	7.99	−0.09
Toluene	110.6	5.37	5.26	−0.11
n-Octane	125.6	6.03	6.10	+0.07
Ethylcyclohexane	131.8	3.55	3.58	+0.03
Ethylbenzene	136.2	4.99	4.59	−0.40
p-Xylene	138.4	5.11	10.51	+0.32
m-Xylene	139.2	5.08		
o-Xylene	144.4	4.22	4.16	−0.06
n-Nonane	150.7	6.31	6.11	−0.20
Isopropylbenzene	152.4	5.98	6.39	+0.41
n-Propylcyclohexane	156.7	6.58	6.65	+0.07
n-Decane	174.0	8.23	8.20	−0.03
Total		100.00	100.00	
		Average difference		±0.20

TABLE 3—ASSAY DISTILLATION (ENGLER) OF THE EAST TEXAS LIGHT AND HEAVY NAPHTHAS
(Data Provided by the Standard Oil Development Co.)

Light naphtha (depentanized)		Heavy naphtha	
Percentage	Temperature (°F.)	Percentage	Temperature (°F.)
Initial	136	Initial	248
2.5	158	2.0	257
37.0	176	7.0	266
77.0	194	27.5	284
98.0	212	47.0	302
Final	216	62.5	320
		74.0	338
		82.5	356
		90.0	372
		91.0	374
		96.0	392
		Final	399

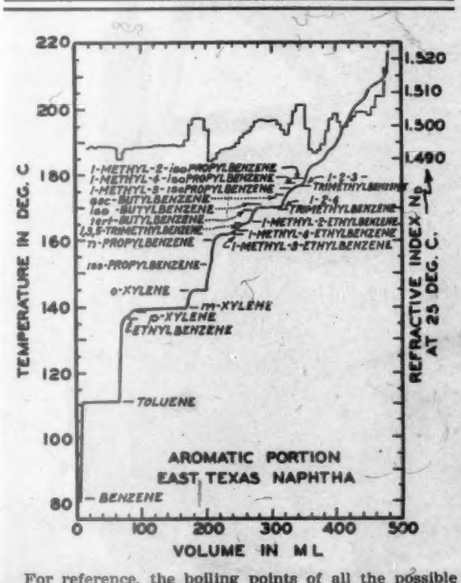


Fig. 3—Plot of the boiling point and refractive index as a function of volume, for the distillation (at a controlled pressure of 770 mm. mercury) of the aromatic hydrocarbons from the East Texas naphtha

For reference, the boiling points of all the possible aromatic hydrocarbons normally boiling below 180° C. are indicated. The data represented here, plus a determination of the freezing point of the mixture of *p*-xylene and *m*-xylene, will serve readily to determine the amounts of each of benzene, toluene, ethylbenzene, *p*-xylene, *m*-xylene, *o*-xylene, isopropylbenzene, and *n*-propylbenzene. Above 160° C., the number of possible aromatic compounds increases rapidly, and the analysis with respect to individual compounds becomes more difficult and less certain (see text).

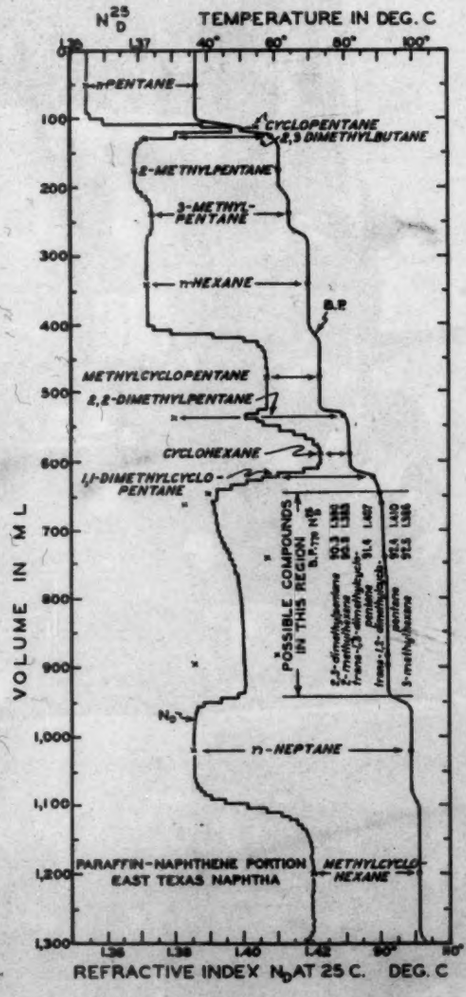


Fig. 4—Plot of the boiling point and refractive index as a function of volume, for the distillation (at a controlled pressure of 770 mm. mercury) of the paraffin and naphthene hydrocarbons from the East Texas naphtha

In the manner previously described, the naphtha was separated into an aromatic portion and a paraffin-naphthene portion. The aromatic portion was distilled in still "O," which is described in Table 1. Fig. 3 shows the boiling point and the refractive index of the distillate from the aromatic portion as a function of its volume. The paraffin-naphthene portion is being distilled in still "P," which is described in Table 1. Fig. 4 shows the boiling point and the refractive index of the first part of the distillate (to 103° C.) from the paraffin-naphthene portion as a function of its volume. Although the data have not yet been reduced to final form, the following approximate figures will give an indication of the amounts of some of the hydrocarbons in this East Texas naphtha, in percentage by volume:

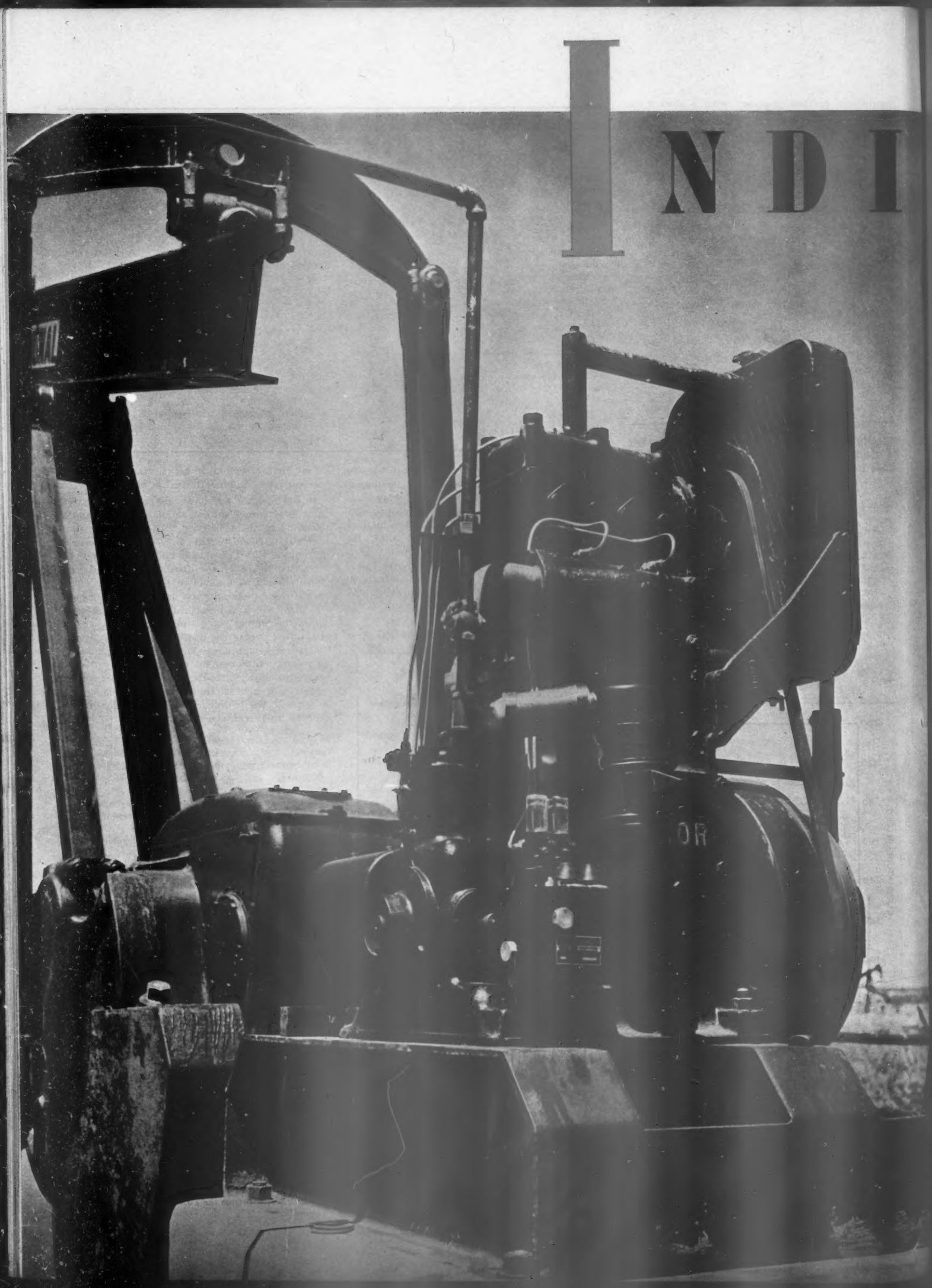
Benzene	0.1	Cyclopentane	0.3
Toluene	1.3	2,3-Dimethylbutane	0.3
Ethylbenzene	0.4	2-Methylpentane	2
p-Xylene	1.6	3-Methylpentane	1.5
m-Xylene		*n*-Hexane	4
o-Xylene	0.6	Methylcyclopentane	3
Isopropylbenzene	0.1	2,2-Dimethylpentane	0.2
n-Propylbenzene	0.1	Cyclohexane	2
		1,1-Dimethylcyclopentane	0.2
		n-Heptane	4
		Methylcyclohexane	5

Preliminary Results on Oklahoma Naphtha

The Oklahoma naphtha being analyzed is from the original Mid-Continent petroleum that has been under extended investigation by the project. The assay properties of this petroleum have been

(Continued on Page 114)

At the time this plot was made, the distillation was about one-third completed. The circles and crosses represent, respectively, the boiling points (at 770 mm. mercury) and the refractive indices (n_D at 25° C.) of the indicated compounds in the pure state. The data represented here will serve readily to determine the amounts each of *n*-pentane, cyclopentane, 2,3-dimethylbutane, 2-methylpentane, 3-methylpentane, *n*-hexane, methylcyclopentane, 2,2-dimethylpentane, cyclohexane, 1,1-dimethylcyclopentane, *n*-heptane, and methylcyclohexane. It is seen that the material of the range 90° to 93° C. (at 770 mm. mercury) is complicated by the presence of several close-boiling paraffin and naphthene compounds.


INDI
OR

SPENSABLE *to Victory...*

...Fuel for ships and submarines, for tanks and trucks, for bombers, fighting planes and trainers. Without petroleum American industrial production will collapse... our fighting services will be helpless.

Power equipment for oil production is likewise indispensable to victory. Its preservation and care is not only a patriotic duty but a National necessity as well.

The thousands of Superior oil field production engines now in service will continue to maintain their full efficiency if the few instructions below are followed.

Lubrication

1 Use only the oil recommended by us or by a reputable refiner. Cheap oil is always expensive.

2 Keep the lubricator filled and inspect it daily to see that each plunger feeds oil at the recommended rate.

3 Keep crankcase oil at the proper level as shown by the gauge—never over-fill.

Ignition System

Adjust spark plug gap weekly to .020". This will prolong the life of the magneto.

Cooling System

1 Keep radiator full of water.

2 Wash out the jackets and the radiator frequently to provide better cooling and increase the life of the radiator.

3 Check the pump stuffing box daily and make any adjustments necessary to forestall leakage.

Gas Pressure

Inspect gas regulator at frequent intervals. Excessive pressure must be avoided.

NSCO
REG. U. S. PAT. OFF.

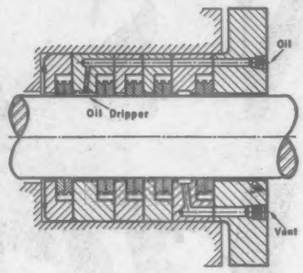
THE NATIONAL SUPPLY COMPANY

Executive Offices: Pittsburgh, Penna. • General Sales Office: Toledo, Ohio • Division Offices: Fort Worth, Texas; Tulsa, Okla.; Torrance, Calif. EXPORT: The National Supply Corporation, 30 Rockefeller Plaza, New York, N. Y., U. S. A.; River Plate House, 12 South Place, London, E. C. 2, *Limited Liability.*

NEXT TIME those packings (that should have been France in the first place) spring a leak, hang out a sign "Gas Drill Today" to attract the nearest company of soldiers for gas mask drill. This is a fine way to serve your country although tolerating improper packing plays hob with your gas compressing costs. Many operators prefer to play safe by insisting on the scientifically-designed packings for which France is the password in any plant. If you're having trouble, remember it's no trouble to "France-pack" your compressor.

In addition to packing, France also makes a great variety of piston rings for engines, pumps and compressors—one piece and multi-piece compression rings, segmental rings, oil control and scraper rings. Information about these products is yours on request.

PACKINGRAM
by
E. A. FRANCE



ANNULAR CASE PACKING
TYPE 414

The Type 414 Packing exemplifies an advanced design in packing construction. The engine or compressor on which it is used must be provided with a stuffing box having an annular space large enough to accommodate the case. Many engine builders, recognizing its worth, have provided stuffing boxes to standards recommended by the France Manufacturing Company.

This packing has an annular type case formed by a series of cups placed against each other to form grooves for the packing rings. The plane surfaces of the cups against which the rings bear are ground, instead of being only machined, to provide a better sealing surface. This type of case has enough metal between the outside diameters of the ring grooves and the box so that tie rods run through the case to hold the packing as a unit. An oil hole is drilled through the heavy sections to conduct lubrication to the most effective point—the pressure end of the packing.

A vent may also be taken off in a gas packing of this type as shown in the cut above.

Three cups and a flange form a three groove case which hold up to 150 pounds pressure. Additional cups are added as higher pressures are encountered. For some gas conditions an auxiliary stuffing box containing several rings of soft packing is incorporated as part of the flange.

The design is equally desirable for air, gas, or steam, and is equipped with packing rings of iron, bronze, Carbon-Bakelite, or carbon as required by the vapor conditions.

CAST IRON RINGS • SCUFF-PROOF CAST IRON RINGS • BRONZE RINGS • CARBON-BAKELITE RINGS • CARBON RINGS

Complete line of packing for all gases up to 15,000 lbs. pressure, as well as for superheated steam engines and gas engines.

FRANCE MFG. CO.

FRANCE MANUFACTURING COMPANY
Belgrade and Orthodox Streets • Philadelphia, Penna.
"Don't Take A Chance—Take FRANCE"

CUT AND BEVEL YOUR PIPE IN 12 MINUTES OR LESS
with the ALSTON RATCHET PIPE CUTTER and BEVELING TOOL

The patented Ratchet Pipe Cutter and Beveling Tool is a sturdy, powerful, easy-to-operate pipe cutter that has been fully tested in the field. Ratchet principle enables operators to work in close places. Bevel tool removes bead on pipe and automatically conditions pipe for welding, threading or sleeving. Cutter may be slipped on or off by simple operation of one pin.

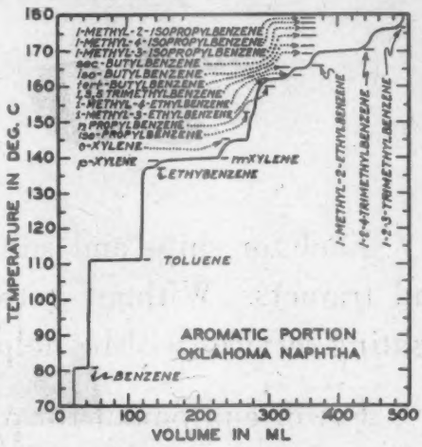
Furnished in straight sizes for specific size of pipe from 6" to 26" and in combinations to handle two sizes of pipe from 6" to 4" and 26" to 24".

Write for details on this superior, money-saving pipe cutter.

MANUFACTURED BY
ALSTON MACHINE SHOP
Exclusive Sales Representative
J. I. HILL COMPANY
1011 SHELL BUILDING • P. 9004 • HOUSTON

given previously.[2] For this investigation, a naphtha fraction was made by taking that part of the crude coming over as distillate between 46° and 180° C. in a column of nearly 100 theoretical plates operated at a reflux ratio of about 15 to 1. This portion represented 35 per cent by volume of the original petroleum. The aromatic content of this naphtha was found to be 9.3 per cent by volume, and the sulfur content 0.017 per cent by weight.

As before, the naphtha fraction was separated into an aromatic portion and a paraffin-naphthene portion. The aromatic portion was distilled in



For reference, the boiling points of all the possible aromatic hydrocarbons normally boiling below 180° C. are indicated. The data represented here, plus a determination of the freezing point of the mixture of *p*-xylene and *m*-xylene, will serve readily to determine the amounts of each of benzene, toluene, ethylbenzene, *p*-xylene, *m*-xylene, *o*-xylene, isopropylbenzene, and *n*-propylbenzene. Above 160° C., the number of possible aromatic compounds increases rapidly, and the analysis with respect to individual compounds becomes more difficult and less certain (see text).

Fig. 5—Plot of the boiling point as a function of volume, for the distillation (at a controlled pressure of 770 mm. mercury) of the aromatic hydrocarbons from the Oklahoma naphtha

still "O." Fig. 5 shows the boiling point of the distillate from the aromatic portion as a function of its volume.

Crude Petroleums to Be Analyzed

In addition to the East Texas and Oklahoma crudes described in this paper, which are intermediate in type, the advisory committee has selected the following crudes as next to be analyzed by this method:

Type—	Field
High aromatic	Conroe, Texas
High paraffin, low naphthene	Greendale-Kawkawlin, Michigan
High isoparaffin	Winkler, Texas
High naphthene	Midway, California
High paraffin, low aromatic	Pennsylvania

References

1. F. D. Rossini, Proc. A.P.I. 18 (3) 36 (1937); The Oil and Gas Journal, 36 (28) 193 (1937); Refiner Natural Gasoline Mfr., 16 (2) 545 (1937).

2. B. J. Mair and J. D. White, J. Research Natl. Bur. Standards, 15, 51 (1935).

3. C. B. Willingham, J. Research Natl. Bur. Standards, 22, 321 (1939).

4. B. J. Mair and A. F. Forziati, restricted report (1942) of A.P.I. Research Project 6 on the separation of aromatic hydrocarbons.

5. C. B. Willingham and F. D. Rossini, A.P.I. Research Project 6.

6. B. J. Mair and A. F. Forziati, restricted report (1942) of A.P.I. Research Project 6 on the analytical determination of aromatic hydrocarbons.

7. F. D. Rossini, Proc. A.P.I. 19 (3) 99 (1938); The Oil and Gas Journal, 37 (27) 141 (1938); Refiner Natural Gasoline Mfr. 17 (11) 557 (1938).

8. M. M. Hicks-Brunn, J. H. Brunn, and W. B. M. Faulconer, J. Am. Chem. Soc. 61, 3099 (1939).

9. M. R. Fenske, private communication (regarding 2,2-dimethylbutane).

"Hey Johnny! Get all you can out of that wire rope..."

"TAKE IT from one of the guys that sails the ships that carry the goods, Johnny, your Uncle Sam needs wire rope today, and needs it bad! Army, Navy, Merchant Marine—the whole shebang uses wire rope, plenty of it! That's why it's up to you guys on the production front to get all you can out of the wire rope *you're* using! Take care of that rope and keep it on the job. And keep right on pumping us the oil to make this war stick right in Hitler's throat."

Here's some pointers to follow in getting all you can out of wire rope and keeping it on the job. They don't cover the whole field of using wire rope by a long shot, but they're precautions that may be overlooked, particularly in times like these. First of all, when you're running a new drilling line through the sheaves, don't take a chance on make-shift fastenings to connect the new line to the old. Use a standard wire rope grip. That way, the new line will run through smooth, without more than normal twisting or untwisting as it follows the old line through.

Next, when you're spooling a new line on the drum, take a few seconds to figure out the position of that line on the drum face in relation to the position of the travelling block on the rig. With the block in pick-up position, the line should never be against the flange of the drum. If it is, the whip in the line as the load is picked up will cause a lot of extra wear at that one point. The same applies to the top position of the block. Arrange your line so that it always has three or more wraps out from the flange at these two critical points.

Finally, about this business of anchoring the dead end of a drilling line. There's lots of ways it can be done. Some of them are right for one kind of rig, some for another. But a general principle applies to dead-end anchorage, whatever system you use. That's simply this: be sure your line is not being cut, gouged, squeezed or bent sharply at the point of fastening. Remember that your anchorage has to absorb all the kicking-around your drilling line gets, that it can't just pass on vibrations like a fiddle string. Every shock and jar in the whole line ends up right there at your anchorage fastening. So be sure to use an approved method.

JAR ROEBLING

We build a lot of extra value and service into "Blue Center" Steel Wire Rope here at Roebling. By taking care of your "Blue Center" ropes, you'll be getting all of that extra value *in production*, which means just that much more oil.

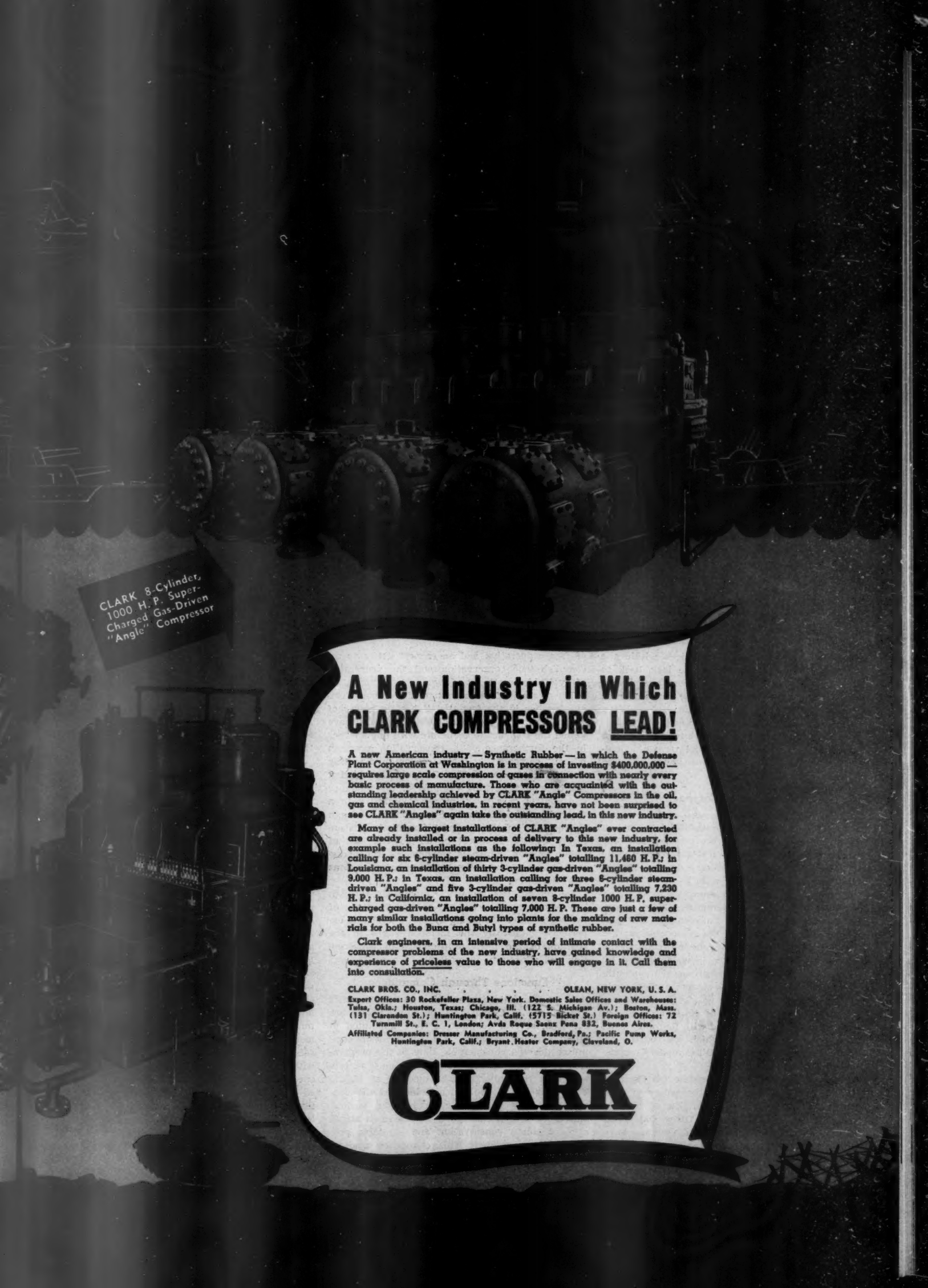
JOHN A. ROEBLING'S SONS COMPANY
TRENTON, NEW JERSEY
Branches and Warehouses in Principal Cities

Distributed by
THE NATIONAL SUPPLY CO.

★ PROMPT SERVICE
★ on essential orders
★ from warehouse
★ stocks

ROEBLING
"Blue Center"
STEEL WIRE ROPE
PREFORMED OR NON-PREFORMED

CLARK Steam-Driven "Angle", offered in 3, 4, 5, 6 and 8-cyl. models, ranging from 500 to 4,000 H.P.
CLARK 3-Cylinder, 300 H.P. Gas-Driven "Angle" Compressor



A New Industry in Which CLARK COMPRESSORS LEAD!

A new American industry — Synthetic Rubber — in which the Defense Plant Corporation at Washington is in process of investing $400,000,000 — requires large scale compression of gases in connection with nearly every basic process of manufacture. Those who are acquainted with the outstanding leadership achieved by CLARK "Angle" Compressors in the oil, gas and chemical industries, in recent years, have not been surprised to see CLARK "Angles" again take the outstanding lead, in this new industry.

Many of the largest installations of CLARK "Angles" ever contracted are already installed or in process of delivery to this new industry, for example such installations as the following: In Texas, an installation calling for six 6-cylinder steam-driven "Angles" totalling 11,460 H. P.; in Louisiana, an installation of thirty 3-cylinder gas-driven "Angles" totalling 9,000 H. P.; in Texas, an installation calling for three 6-cylinder steam-driven "Angles" and five 3-cylinder gas-driven "Angles" totalling 7,230 H. P.; in California, an installation of seven 8-cylinder 1000 H. P. supercharged gas-driven "Angles" totalling 7,000 H. P. These are just a few of many similar installations going into plants for the making of raw materials for both the Buna and Butyl types of synthetic rubber.

Clark engineers, in an intensive period of intimate contact with the compressor problems of the new industry, have gained knowledge and experience of priceless value to those who will engage in it. Call them into consultation.

CLARK BROS. CO., INC. . . . . OLEAN, NEW YORK, U. S. A.

Export Offices: 30 Rockefeller Plaza, New York. Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Texas; Chicago, Ill. (122 S. Michigan Av.); Boston, Mass. (131 Clarendon St.); Huntington Park, Calif. (5715 Bicket St.) Foreign Offices: 72 Turnmill St., E. C. 1, London; Avda Roque Saenz Pena 832, Buenos Aires.

Affiliated Companies: Dresser Manufacturing Co., Bradford, Pa.; Pacific Pump Works, Huntington Park, Calif.; Bryant Heater Company, Cleveland, O.

CLARK

Coordination of Conservation Practices in the Various States

By E. G. DAHLGREN
Interstate Oil Compact Commission, Oklahoma City, Okla.

A.P.I.

This paper discusses the coordinating activities of the Interstate Oil Compact Commission in the conservation of oil and gas in the various states. The work of the various compact committees is described, and the conservation policies and administrative activities in the various oil-producing states are summarized.

Paper presented before Division of Production, at the annual meeting of the American Petroleum Institute, Chicago, November 9-13, 1942.

THE term "coordination" has become popular in this national emergency which has required all of the nation's resources to be marshaled and thrown into a concentrated spearhead to defend our way of life.

The oil industry, state authorities, and federal agencies have set up coordinating agencies to further the war effort.

In fundamental principle, coordination is the basis of the Interstate Oil Compact Commission. The commission is not clothed with arbitrary power, but only with the right to coordinate existing agencies and authorities of power in all branches of government: state, national, and interstate. The degree of success of the principle of coordination depends upon the degree of cooperation given by the states, by industry, and by interstate and governmental groups.

The Interstate Oil Compact Commission has tendered its facilities to the President of the United States, to the petroleum coordinator for war, and to other federal and state governmental agencies in the war effort.

In order adequately to cover the work of the Interstate Oil Compact Commission in the coordination of conservation practices within the various states, it is necessary to look back to the period from 1925 to 1931 when overproduction problems were created by the unprecedented discoveries of vast productive fields such as Yates, East Texas, Seminole, and Oklahoma City. Statutes requiring purchasers of oil to buy ratably from the producers in a common pool were of doubtful constitutionality, and were never enforced effectively.

Evolution of Compact

In 1931 the situation became so acute that martial law was invoked in the East Texas and Oklahoma City fields to curb overproduction. The first real semblance of an interstate compact came at the request of the secretary of the interior, whereupon the governors of 10 of the oil-producing states appointed representatives to serve on the Oil States Advisory Committee. This committee met at intervals, and suggested to the producing states estimates of the reasonable market demand. This committee functioned until the period in which the petroleum code, created by the National Recovery Act, introduced the monthly allocation system based upon studies made by the Bureau of Mines.

Upon the dissolution of the National Recovery Act, overproduction, attended with flagrant waste, again beset the industry, which spurred the organization of the Interstate Oil Compact Commission in 1935.

Since its inception the Interstate Oil Compact Commission has adhered to the policy of prevention of waste in the production of oil and gas. The six charter states of Texas, Oklahoma, Illinois, Kansas, New Mexico, and Colorado have now been augmented by the addition of Michigan, Arkansas, Louisiana, New York, Pennsylvania, and Kentucky. Since its organization the Compact Commission has reduced appreciably the initial antagonism and rivalries among the various states, and has brought instead a general feeling of free cooperation and an earnest desire to accomplish true conservation and the prevention of avoidable waste.

The strength of the Interstate Oil Compact Commission lies in the fact that it has no power of compulsion. The member states voluntarily have joined the compact to cooperate with one another in the furtherance of a conservation program without surrendering their freedom in handling their own resources. The Compact Commission has become a working example of the guidance and control of a most important industry in a truly democratic manner. State control, through the medium of the Compact Commission, is enforced by the strongest of all powers, that of public opinion, which is amenable to the necessary changes to meet the requirements of various local conditions.

The Interstate Oil Compact Commission, through its various committees, has taken advantage of the opportunity of making available to all the experience gained by the member states in the solution of the intricate problems of conservation and allocation.

Functions Through Committees

At the organization meeting of the Compact Commission in Oklahoma City, Okla., September 12, 1935, several committees were appointed to study various problems. The conservation committee devoted considerable time to the preparation of a comprehensive report which was presented at the July 31, 1936, meeting at Dallas, Tex. This report codified and indexed the conservation laws and regulations of the various states. In 1939 a committee on minimum standards of sound conservation and equitable proration was appointed. This committee made a report at the July 19, 1939, meeting at Santa Fe, N. M.

On August 23, 1940, upon recommendation of the committee on uniform proration practices, the legal, engineering, and regulatory-practices committees were created to make studies. The legal committee studied the laws of the various oil-producing states, and prepared a model law for recommendation by the commission to all oil-producing states. The engineering committee, after months of hard work, prepared a comprehensive report which compiled and summarized established engineering principles and sound conservation practices. This report was released at the New Orleans meeting, April 14, 1941. The regulatory-practices committee prepared a comprehensive set of rules and regulations available to regulatory bodies of the oil-producing states in promulgating their rules and regulations.

Legal Committee

The legal committee of the Interstate Oil Compact Commission has been doing some outstanding work during the past year. At the December 19, 1941, meeting of the Compact Commission in Oklahoma City, the legal committee adopted the program as follows:

1. A study of the suggested model conservation law for the purpose of making any necessary amendments and corrections.
2. A study of the legal phases of repressuring and recycling.
3. Preparation and publication of synopses of all the statutes of the various oil-producing states.
4. A study of the relationship between the federal Government and the states concerning the legal aspects of oil and gas conservation.
5. The preparation of a skeleton statute that might be advisable in nonproducing states or in states with small production.

At the spring quarterly meeting (March 1942) of the Compact Commission, at Little Rock, Ark., the legal committee recommended that the various member states make a study of their laws, having in mind the enforcement of pooling or consolidating provisions, or any other provisions that may be of assistance in promoting compliance with the provisions of Conservation Order M-68, promulgated by the War Production Board. The legal committee also recommended the enactment of a law to authorize the president to request or approve any cooperative effort found desirable in the national interest. The legal committee also recommended to the various member states the enactment of state statutes to accomplish the same purpose with reference to state antitrust laws. At the summer quarter meeting at Lexington, Ky. (June 1942), the legal committee recommended that every oil-producing state pass an adequate law specifically authorizing agreements with respect to secondary-recovery and related operations. The legal committee also recommended that such agreements, if approved by specified state agencies, shall not violate the antitrust laws. The legal committee presented a comprehensive report regarding the suggested legislation. At the fall quarterly meeting in Chicago (October 1942) the legal committee advocated the enactment of laws pertaining to natural-gas operations.

The coming legislative sessions of many of the oil and gas-producing states doubtless will see

W. A. BECHTEL CO.

San Francisco

some proposed legislation pertaining to oil and gas. The work of the legal committee will be of great benefit to the legislatures of these states. Many of the states already are availing themselves of the work done by this committee in preparing future legislation.

Research and Coordinating Committee

In December 1941, the research and coordinating committee was appointed. With the exception of the Pennsylvania and Colorado members, this committee is composed of technicians who are employed by the regulatory bodies in their states. The function of this committee is to assemble and disseminate factual and technical data showing results of applied conservation in the various states.

The research and coordinating committee adopted a program involving the exchange of information between the members showing the data being collected by the various conservation agencies and the use to which such data is put. These data include bottom-hole pressure determinations, gas-oil ratios, water production, field production history, and type of production control in such fields. The committee also decided to study completion practices, the advisability of permitting dual completions, recoverable reserves and the availability of these reserves, and to compile information as to the types of crude produced from the fields of the various states.

In March 1942, this committee assisted the regulatory bodies in the various states by working out uniform standards in estimating oil reserves and sustained rates of production, as requested by the Office of Petroleum Coordinator for War.

At the spring quarterly meeting March 27, 1942, at Little Rock, the research and coordinating committee reported that a program of cooperation with the Bureau of Mines had been initiated in the collection of crude-oil samples from new pools, new horizons, and other pools for analysis by the Bureau of Mines laboratory at Bartlesville, Okla. To date this program has been carried on successfully as an example of one phase of cooperation and coordination in the interest of aviation-gasoline supplies. At the Little Rock meeting arrangements were made with the National Stripper Well Association for the interchange of data and mutual cooperation in a national survey of stripper wells. Statistical reports on various phases of the petroleum industry were authorized.

In the survey of secondary-recovery and pressure-maintenance operations at the summer quarterly meeting at Lexington, June 19, 1942, the research and coordinating committee recommended to the regulatory agencies of the various member states that engineering data be obtained on each new field for the purpose of providing data for the most efficient installation and operation of secondary-recovery projects.

At the Lexington meeting the committee presented a state-by-state survey of secondary-recovery and pressure-maintenance operations.

At the fall quarterly meeting in Chicago, October 2, 1942, the research and coordinating committee had a round-table discussion of natural-gas developments by states. In the committee report, presented October 3, the committee recommended that the regulatory bodies in each state and other interested organizations make an intensive study of the reserves, production, and utilization of gas in each oil and gas reservoir. The committee recommended that gas be utilized in some manner or sealed off until the gas can be used. The committee also recommended the greater use of natural-gas storage projects and the general adoption of well-testing procedures which do not involve waste of gas.

Through the medium of members of the research and coordinating committee, information has been obtained regarding conservation practices, policies, and administration in the various states.

Alabama

Although Alabama has as yet no oil and gas production, it does have an oil and gas conservation law, and an oil and gas board to administer the law through the state geologist. This law was passed in 1940, is modeled largely after the New Mexico law, requires drilling permits ($25 each), the filing of a bond to insure compliance with the regulations issued under the act, the filing of logs, electrical and otherwise, and the lodgement of cuttings, cores, etc., all in the office of the state geologist. The board is given no right to prorate until a daily production of 50,000 bbl. per day for 90 consecutive days has been reached. Up to date the law has been useful chiefly in securing proper plugging of dry wells, and in adding to geological information by securing for the public well logs and cuttings.

Arkansas

The conservation policy in Arkansas has been designed upon an engineering basis, and has been followed with the aim to profit by the experience gained by other states in the production of oil and gas. The conservation statute, adopted February 14, 1939, is unique in that it does not require the determination of market demand.

It is interesting to compare the present conservation practices in Arkansas with the recommendations published recently in Progress Report on Standards of Allocation of Oil Production Within Pools and Among Pools, by members of the American Petroleum Institute special study committee and legal advisory committee on well spacing and allocation of production.

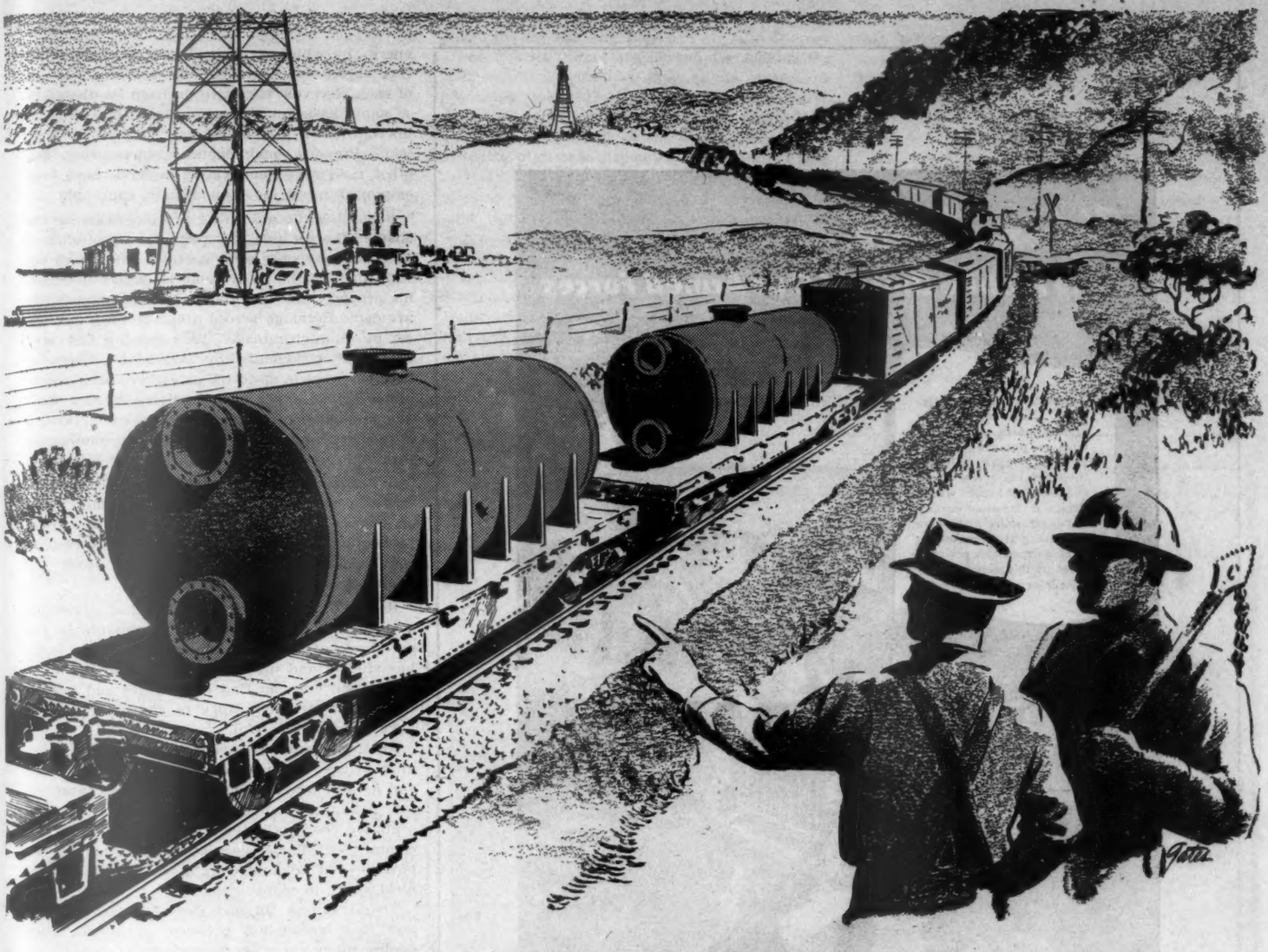
With regard to waste prevention, the Arkansas Oil and Gas Commission controls each oil reservoir in such a manner as to utilize to best advantage the natural agencies and sources of

WATCH FOR THE SKELLY SIGN OF SERVICE AND SATISFACTION

SKELLY

◆ FORTIFIED TAGOLENE MOTOR OIL
◆ FORTIFIED SKELLY GASOLINE
◆ FORTIFIED SKELLY PREMIUM GASOLINE
◆ SKELLY GREASE-MASTER SERVICE

SKELLY OIL COMPANY
TULSA, OKLA. KANSAS CITY, MO.



There Goes the New "V...—" Type Lucey Oil Country Boiler . . .

These "boilers" are actually Converters made by us for a nitrate plant at an "undisclosed location". Thus, explosives can be added to the ever-growing list of war goods made possible by Lucey cooperation. For nearly two years now we have furnished Nun Buoys, Aluminum Ladles, Blow Off Tanks, Stack Bases, Stacks and plate work of all kinds for the Navy, Shipyards and Defense Plants.

Keep The Steam UP!

Since boiler materials are needed so greatly by the Ship Building Industry, it is fortunate that Lucey Oil Country Boilers require so few spare parts. However, you can make boilers last longer — serve you better — by writing us for the complete information contained in the API bulletin, "Recommended Field Practice."

Lucey Steel Jacketed Insulation will improve the efficiency and increase the life of any boiler. Water treatment also adds greatly to boiler life.

DISTRIBUTORS

Lucey Products Corporation, Tulsa, Oklahoma
Frick-Reid Supply Corporation, Tulsa, Oklahoma
Houston Oil Field Material Company, Inc., Houston, Texas
Murray-Brooks Hardware Company, Ltd., Lake Charles, Louisiana
Petroleum Equipment Company, Los Angeles, California

EXPORT: Lucey Export Corporation, 3505 Woolworth Bldg., New York, N. Y., Broad Street House, E. C. 2, London, Eng.

Get In The Scrap!

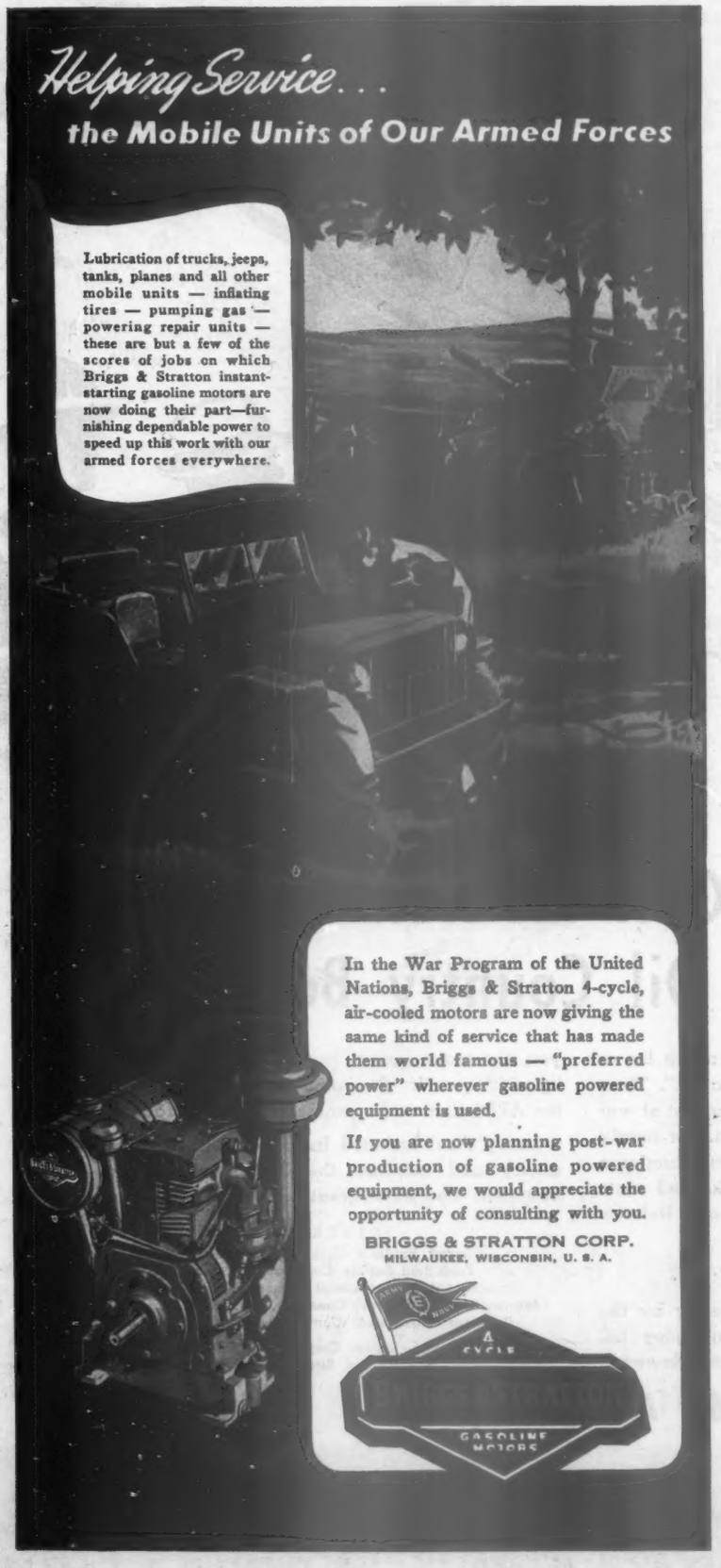
LUCEY

LUCEY BOILER and MANUFACTURING CORPORATION

Chattanooga, Tenn.

2800 SOUTH ALAMEDA ST.
LOS ANGELES, CALIFORNIA

811 STERLING BUILDING
HOUSTON, TEXAS


Helping Service . . .
the Mobile Units of Our Armed Forces
Lubrication of trucks, jeeps, tanks, planes and all other mobile units — inflating tires — pumping gas — powering repair units — these are but a few of the scores of jobs on which Briggs & Stratton instant-starting gasoline motors are now doing their part—furnishing dependable power to speed up this work with our armed forces everywhere.
In the War Program of the United Nations, Briggs & Stratton 4-cycle, air-cooled motors are now giving the same kind of service that has made them world famous — "preferred power" wherever gasoline powered equipment is used.
If you are now planning post-war production of gasoline powered equipment, we would appreciate the opportunity of consulting with you.
BRIGGS & STRATTON CORP.
MILWAUKEE, WISCONSIN, U. S. A.
4 CYCLE
GASOLINE MOTORS

energy by which oil is produced. In maintaining this objective, a detailed and continuous study of each reservoir is carried on from its discovery. A sound basis for gas conservation has been followed. Water production has not been a problem. Pressure maintenance, repressuring, and other field-wide conservation methods have been employed whenever economically applicable.

Regarding allocation within pools, Arkansas has adopted the formula of acreage times bottom-hole pressure to enable each operator to recover the equivalent of the recoverable oil which underlies his property, and in order to prevent reasonably avoidable drainage across property lines not offset by counterdrainage. Well spacing has been controlled stringently by Arkansas. Whenever necessary, tracts up to 160 acres have been pooled either by voluntary or compulsory means. Only one well has been allowed to a unit. Pooling of royalty interests is required in compulsory formation of a drilling unit.

Allocation among pools has not been a problem in Arkansas, as each pool is operated solely upon an engineering basis, with the optimum rate of production observed. It has not been necessary for Arkansas to adopt a definite basis for equitable allocation among pools.

Regarding procedure, Arkansas has developed a splendid feeling among the inhabitants in the excellence of their conservation policy. Arkansas has studied and utilized the experience of other states, and one can find in its rules and regulations excerpts from rules of other states that have proved successful.

All employes of the Arkansas Oil and Gas Commission are required to be qualified petroleum and natural-gas engineers, petroleum accountants, etc. Arkansas encourages the formation of representative cooperative engineering associations or committees. These associations and committees have proved advantageous in collaborative technical study in many areas.

The Arkansas Oil and Gas Commission operates four bottom-hole pressure units and other equipment to carry on its engineering studies.

California

Although not a member of the Interstate Oil Compact Commission, California has displayed great interest in the activities of the commission. California was one of the original states that assisted in the formulation of the compact, but a militant minority has blocked efforts for California to join.

As California has no allocation control law. the production committee for District 5, created by the Office of Petroleum Coordinator for War, must develop methods of allocation which meet with the approval of the federal Government. All allocation schedules must be approved by the chief counsel of the Office of Petroleum Coordinator. Allocation of oil production in California has been required to be made in accordance with recognized engineering principles of production to obtain the most efficient production of all pools. The engineering subcommittee of the production committee for District 5 has devoted considerable effort to determine efficient rates of production. The Conservation Committee of California Oil Producers, through its office of administrator, administers the details of allocation.

Illinois

Conservation legislation in Illinois has been fought by a militant group that has opposed any oil and gas regulations. However, a law was passed in June 1941, which empowers the Department of Mines and Minerals to issue and enforce rules and regulations regarding drilling, casing, plugging, filing of logs, well spacing, etc. The Department of Mines and Minerals has been given the power to issue permits for drilling, water flooding, and salt-water disposal.

The Oil and Gas Conservation Division of the Department of Mines and Minerals has been conducting meetings and conferences with representatives of the oil, gas, and coal industries in the preparation of a comprehensive set of rules and regulations.

The Department of Mines and Minerals has kept in close touch with activities in other states, and has been diligent in protecting the interests of the oil industry.

The Illinois law expressly forbids the limitation of production of any well, leases, and pools to prevent or control economic waste or limit production to market demand.

Indiana

The Department of Conservation through the division of geology administers oil and gas conservation regulations in Indiana.

The state gas supervisor, with the assistant supervisor and deputy gas inspectors, procure the enforcement of laws and regulations pertaining to the search for development and production of petroleum and natural gas; supervise the plugging of dry and abandoned wells; and inspect field and pipe-line equipment to eliminate wastage of oil and gas, and prevent pollution of water courses by oil or salt water. In addition, the staff collects and compiles geological and production data which are made available to the public through several publications. These deputy gas inspectors receive no salary, but are reimbursed through a percentage of the fees for supervision in plugging wells.

Oil and gas-drilling permits are issued by the Department of Conservation.

Kansas

The Kansas State Corporation Commission has kept pace with the other oil-producing states in adopting improvements in conservation practices. The most outstanding feature of the Kansas allocation system is the usage of the so-called "log-log" curve, a mathematical formula, to provide an equitable distribution of the state's allowable among the pools. This system is peculiarly adapted to Kansas, in that most of the pools are similar in physical characteristics and that the pipe-line systems are distributed evenly over most of the area of curtailed production.

The Kansas State Corporation Commission, through its Conservation Division, always has kept in close touch with the advance in engineering technique. An illustration in point is the use of the drawdown tests for the determination of potentials. A paper on this subject by Haely* illustrates the great savings afforded operators in the elimination of costly pumping equipment necessitated by the old regulations which required capacity pumping tests which frequently brought on premature water encroachment. At the present time the Kansas Corporation Commission has three bottom-hole pressure bombs for use in the determination of potentials.

Louisiana

The State of Louisiana has charged the commissioner of conservation with the responsibility of enforcing the laws relative to the conserving of oil and gas as well as those relative to wild life, fisheries, forest, etc. For the satisfactory consummation of these objectives, the commissioner has delegated to the director of the Division of Minerals and his staff the activities relating to oil and gas. The Division of Minerals has divided the state into six districts—Houma, Lafayette, Lake Charles, Monroe, New Orleans, and Shreveport—in order properly to administer the various rules, regulations, and orders promulgated by the commissioner of conservation under the laws of the state.

The district offices are located throughout the state in towns and cities serving the several oil-producing fields. The district offices are staffed with a manager, usually a petroleum engineer or a man of like qualifications, from three to five assistant engineers, depending upon the activity in the district, and a like number of agents or inspectors. The agents or inspectors are men who have worked in the oil fields, but who have no technical training. One or two stenographers complete the roster.

The district office is required to supervise the drilling, completion and production of wells. All applications for permits to drill or do work on a well are filed with the district office, and all permits are issued there with the exception of the original permit to drill, which is issued from the main office. Likewise, all reports dealing with production of oil and its movements first are checked in the district office for correctness before they are passed on to the main office for final examination.

The largest job of the division is to prevent waste, both surface and underground.

A spacing and proration order for a particular field is issued by the commissioner of conservation after a request or petition by a person or company operating in that field. The law requires that due notice be given to interested parties prior to a public hearing, and that such notice be published in the official journal of the state and in a news medium of the parish in which the field is located. At the public hearing testimony is heard and incorporated in the records as to the probable limits of production, the character, permeability, and porosity of the producing formation, as well as cross-sections and

*J. F. Haely, "Methods and Application of Determining Well Potentials," American Petroleum Institute, Division of Production, Mid-Continent district meeting, Oklahoma City, Apr. 18, 1939.

YESTERDAY THE HELPERS IN THIS CREW KNEW NOTHING ABOUT APPLYING NO-OX-ID RUST PREVENTIVE TO PIPE . . .

. . . BUT THIS MAN MADE THEM *Efficient Operators* IN ONE DAY . . . IT'S SO EASILY DONE

That's important these days with men going into the armed services and the consequent difficulty of keeping crews intact.

The machine illustrated is practically automatic. It coats the pipe surface with NO-OX-ID and applies the NO-OX-IDized Wrapper simultaneously in one operation. The heaviest manual labor is feeding the pipe at one end and removing the completely NO-OX-ID protected pipe at the other end.

NO-OX-ID is double acting . . . it prevents rust mechanically by excluding moisture and oxygen and chemically by inhibiting any underfilm corrosion which may be present. A combination of NO-OX-ID and NO-OX-IDized Wrapper provides pipe line protection under the most corrosive soil conditions. Pipe lines, laid a quarter of a century ago, are still in service requiring no maintenance through the years.

Dearborn engineers are at your service to help you solve your rust problems. Also to demonstrate how a combination of NO-OX-ID and NO-OX-IDized Wrapper provides complete protection and can be applied rapidly and easily by stationary machines such as illustrated, by travelling machines on the line, or by hand. Write for complete details. Dearborn Chemical Company, Dept. K, 310 S. Michigan Avenue, Chicago, Illinois.

NO-OX-ID IRON OXIDE RUST
the original rust preventive

NO-OX-ID treated service lines laid under city streets are down to stay, needing no maintenance.

12" Gas line treated with NO-OX-ID and NO-OX-IDized Wrapper being laid on a river bed where the line is actually exposed to the corrosive action of water.

When "hot spots" cause pitting, NO-OX-ID can be hand applied in the reconditioning operation.

contour maps of the reservoir and other pertinent and correlated data.

The party petitioning the commissioner for a spacing order is allowed to present his case, his expert witnesses testify under oath and, after direct examination, the opposition and likewise the commissioner have the right to crossexamine the witness following approximately the same procedure as that used by other regulatory bodies. Haggling and irrelevant questioning are not tolerated. The commissioner only desires information which will be of assistance to him and his staff in establishing the proper spacing unit and producing program for the field in question.

In North Louisiana the first spacing and proration order was written for the Rodessa field. The effect of this order was to reduce the gas waste by at least 75 to 80 per cent. In the Lisbon field the 40-acre spacing order saved the operators thousands of dollars. Even with a 40-acre order, the operators and the land and royalty owners soon found that the amount of recoverable oil would not give satisfactory "payout" on the wells. It is only by the unitizing of small tracts of land that the small land and royalty owner can obtain his just and equitable share of the reservoir.

When the Shreveport field was discovered in July 1938, on the outskirts of that city, the cry was immediately, "another townlot drilling program." On March 1, 1939, the Department of Conservation promulgated Order 13 to regulate the drilling operations. This order was the first one in which the machinery was set up to require the pooling of lease interests into 40-acre drilling units and, as a consequence, the field was drilled in a very orderly fashion. After the Shreveport order came those for Sugar Creek and the La Salle Parish area, both providing for 40-acre spacing programs.

Not all the advancement in proration and spacing orders has been made in North Louisiana. In fact, development of the oil industry in South Louisiana is much further advanced. Spacing orders have been issued for such fields as Eola, Barataria, Jennings, La Fourche Crossing, Golden Meadow, Stella, and Anse La Butte.

The Anse La Butte order is unique in that it is the first spacing order ever written for a piercement-type dome field in any state. To date this order has operated with fair success, and has caused the development to proceed in an orderly fashion and at the same time has saved the operators much capital, because small properties had to be unitized before the well or wells could be drilled. Many unnecessary wells were not drilled. Allowables were maintained at maximum figures, as the orderly development allowed the operators to anticipate their production and thereby to make the necessary arrangements to dispose of their product. The geographical position of the state definitely is favorable for large allowables.

Two of the outstanding accomplishments in conservation in recent years are the complete unitization of two entire gas-condensate fields—Cotton Valley and South Jennings.

Since Act 157 of 1940 adopts a regulatory system based on engineering and geological interpretations, its enforcement requires skilled and trained engineers and attorneys well grounded in the intricacies of the petroleum industry, from both the state's and the operator's viewpoints.

Michigan

The provisions of the Michigan oil-conservation law (in effect since May 1939) that deal with the locating, drilling, prevention of waste (both market and physical), other operating phases, plugging and violations, are largely patterned after those of other states, such as New Mexico and Louisiana. The parts having to do with the administrative agency to administer the law are different, and in some respects perhaps are unique.

The law states that the director of conservation shall act as the supervisor of wells. The director is appointed by the Conservation Commission, and serves at the pleasure of that commission.

The supervisor appoints six men to be known as the Oil Advisory Board, to advise and consult with him and make recommendations to him for the issuance of rules, regulations, and orders. Of the six men on the advisory board three must be independents and three must be from major companies. In selecting them, the supervisor must consult with the industry and their eligibility is based on training, experience, and standing in the industry. They are appointed for 3-year terms, with the term of one independent and one major expiring each year. Their appointment must be confirmed by the Conservation Commission. The members serve without pay, but are allowed expenses to attend official meetings. The law requires that the board meet once a month and to elect annually a chairman and a vice chairman, and to appoint a secretary.

All rules, regulations, and orders are issued by the supervisor. Rules and regulations must be approved by the Conservation Commission, but orders do not have to be approved by the commission.

The supervisor can issue an "emergency order," which shall be in force for only 21 days. Otherwise rules, regulations, and orders cannot be issued without first having a public hearing, and then, must have a recommendation by the advisory board. After the board has been made its recommendation, the supervisor can follow it, ignore it, or change it, but he must have a recommendation first.

The law provides that the supervisor shall appoint such suitable assistants as may be neces-

ON GUARD TO KEEP

YOUR ENGINES RUNNING

● Here is a sentry that never sleeps!

A Penn safety control, mounted on your internal combustion engine, is on constant watch to prevent damage or interruption of operation.

At small cost you can provide this automatic protection for all of your engines. Penn controls are quickly, easily mounted on gas, gasoline or Diesel engines—old or new. In case oil pressure drops dangerously low or the cooling water system fails these automatic sentries will sound an alarm..light a signal light..or, if desired, shut down engine operation.

By giving advance warning of impending trouble Penn controls enable you to remedy the fault before serious damage or interruption of service occurs.

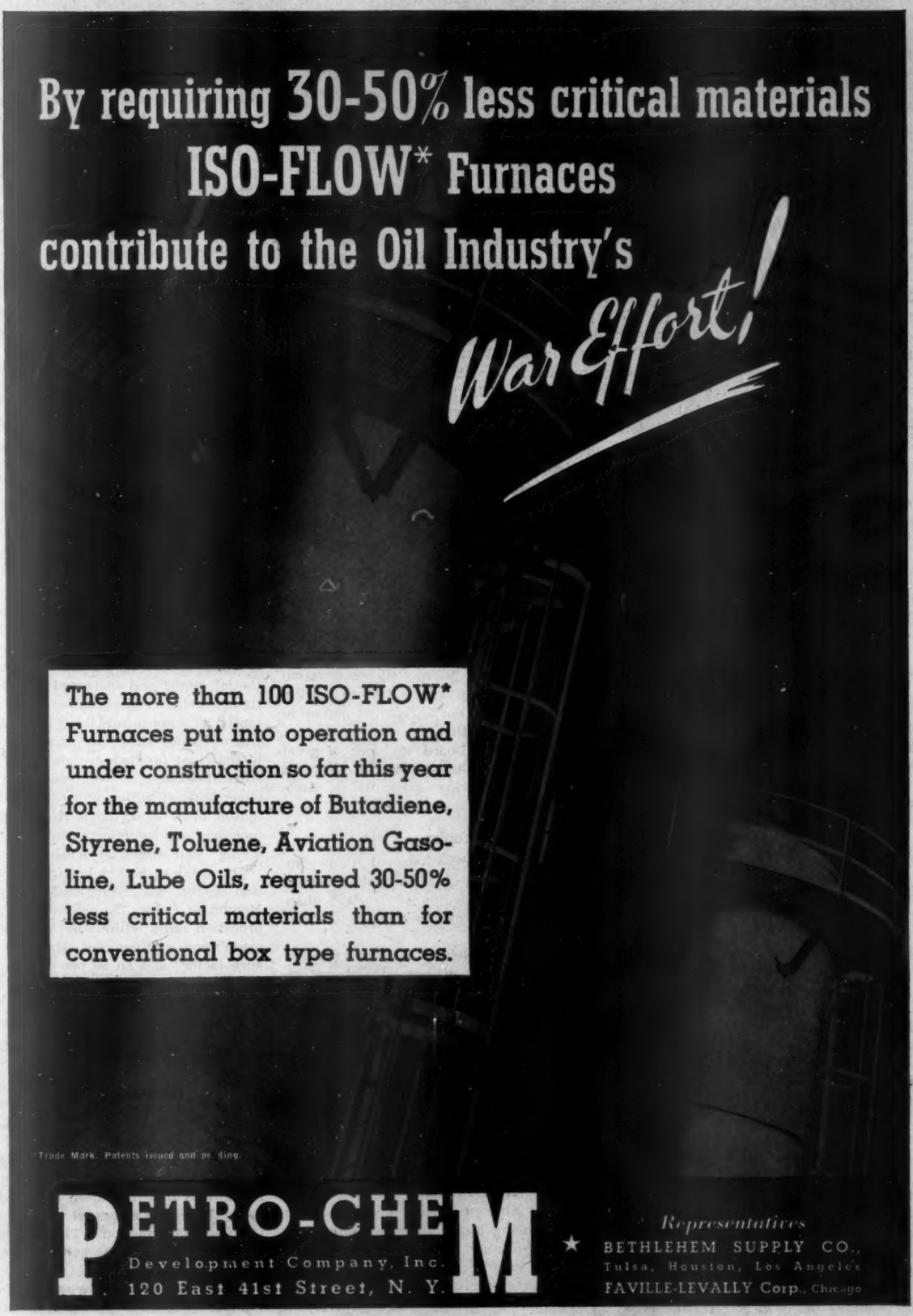
It's good business at any time to have this low-cost protection..during the war emergency it's more important than ever. Why not write *now,* for complete information, without obligation. Ask for catalog E-100.

Penn Electric Switch Co., Goshen, Indiana

PENN CONTROLS

REFRIGERATION AIR CONDITIONING ENGINE HEATING PUMPING AND AIR COMPRESSOR

By requiring 30-50% less critical materials ISO-FLOW* Furnaces contribute to the Oil Industry's War Effort!



The more than 100 ISO-FLOW* Furnaces put into operation and under construction so far this year for the manufacture of Butadiene, Styrene, Toluene, Aviation Gasoline, Lube Oils, required 30-50% less critical materials than for conventional box type furnaces.

Trade Mark. Patents issued and pending.

PETRO-CHEM
Development Company, Inc.
120 East 41st Street, N. Y.

★ *Representatives*
BETHLEHEM SUPPLY CO., Tulsa, Houston, Los Angeles
FAVILLE-LEVALLY Corp., Chicago

sary to perform the duties prescribed. These appointments are subject to approval by the Conservation Commission. Since 1925 the geological survey division of the Department of Conservation has handled the enforcement of the law, rules, regulations, and orders.

Some of the rules and regulations are state wide in application. They are so drawn that, when some situation arises, such as a casing and cementing program for a new field, the geological survey division confers with the operators of that field and work out the requirements without using a new rule. In other instances the field engineers work a problem out with the operator at the well, or on the lease, as it comes up. On the spacing of wells there is a general rule, but it is the policy to issue special rules for a new field if the operators request it. This is done after hearing and recommendation of the board.

The matter of proration is a separate one, and is not covered by the general rules. In prorating a field or fields, orders are issued generally after a public hearing, but it has been necessary to issue a number of emergency orders.

In considering proration for a field, all the facts are obtained and analyzed. The engineers of the geological survey working continuously with the engineers of the oil companies and information is exchanged. From these data a report is prepared each month which is studied by the supervisor and the board, and used as a basis for deciding whether to continue proration as is or call a public hearing to hear evidence and testimony on the need or desirability of changing the allowables.

To date allowables have all been on a flat per-well basis. No potentials are taken. An operator does take a test each month at the allowable rate, and determines gas-oil ratios, reservoir pressure, water production, etc.

Gas-oil ratios of the Michigan fields are low. It is the practice to allow the wells to produce all they can at the lowest gas-oil ratio. If the total allowable on this basis is more than the market demand, then the allowables are adjusted to that demand.

One of the provisions of the law is that a well cannot be drilled for oil or gas without a permit, for which there is a fee of $25. If the applicant is not complying with the law or the rules, regulations, and orders, the supervisor is without authority to issue a permit. This is an effective method of securing compliance and of clearing up situations that are not in line with good operating practice. Even though a permit can be denied without first advising an operator that he cannot get one, it is not done in that manner. If an operator is believed to be in violation, a letter in detail is written to him requesting him to work out a mutually satisfactory solution with the geological survey division. In nearly every case of this kind a solution is found in the field. It is the exception to have to refer the matter to the supervisor with the recommendation that the matter be prosecuted.

The Department of Conservation believes the Michigan law is a good one, but the strong point is that the operators as a whole give excellent cooperation. The industry in Michigan is not large; therefore, personal contacts are possible between the operators and the geological survey division, resulting in solving practically every problem.

The policies and practices rather closely follow the recommendations made by the Institute's study committee, previously cited.

Mississippi

The Mississippi conservation laws are under the control of a state Oil and Gas Board, composed of the governor, attorney general, state land commissioner, and a state oil and gas supervisor appointed by the governor. This board has general power to make rules and regulations for the conservation of crude oil and natural gas. A fee of $25 is required for a permit to drill. The state Oil and Gas Board has not exercised its powers to prorate the oil production in the Tinsley field, the only large producing field in Mississippi.

Withdrawals are limited from gas wells to a certain percentage of the open-flow capacity, depending upon the size of the tract, varying from 24 per cent on a spacing of 160 acres to 7 per cent on a spacing of 5 acres.

Montana

The Oil Conservation Board of Montana has sent observers frequently to the quarterly meetings, and has kept in close touch with the Interstate Oil Compact Commission, although not a member.

The petroleum industry in Montana did not assume importance until the discovery of the Cat Creek field in 1920. At that time the only conservation provision was the requirement to plug wells in accordance with simple specifications. In 1925 the lack of a state control law, and the absence of bonding requirements was abused to such an extent, that the state legislature passed a law which empowered the Board of Railroad Commissioners to supervise the drilling, abandonment, and plugging of oil and gas wells on all lands, except those owned by the United States, and required the board to adopt the same regulations from time to time prescribed by the Bureau of Mines.

In 1933 the petroleum code aroused interest in the adequacy and status of Montana laws on the subjects covered by the code. Investigation disclosed weaknesses in existing laws which resulted in the enactment of the "oil conservation law." This law originally was limited to the life of the petroleum code, but legislative action in 1935 removed the limitation.

The Oil Conservation Board has been of great service to the state and the petroleum industry. It has served as a coordinating agency for all petroleum matters in Montana.

Nebraska

The Nebraska Legislature enacted a law, approved May 23, 1941, giving the state geologist jurisdiction over the plugging of dry and abandoned wells. Operators are assessed the actual costs and expenses.

At the present time Nebraska is interested in the proper development of her oil and gas resources. Governor Griswold has directed Allen G. Burke, director of the Nebraska Department of Agriculture and Inspection, to handle oil and gas matters.

Charles L. Orr, secretary of the Interstate Oil Compact Commission, at the invitation of the Nebraska Legislative Council, discussed oil and gas conservation and the coordinating activities of the Interstate Oil Compact Commission at a meeting in Lincoln on March 9, 1942.

New Mexico

Proration was initiated in New Mexico early in the state's producing history by the adoption of the "operator's proration agreement." This method was legalized in 1929 by a law which provided that the operator's proration agreement must be approved by the state geologist and the commissioner of public lands. The state geologist constitutes the oil-and-gas regulatory arm of the state. The operator's agreement restricts production within the compass of market demand. The 40-acre unit of production was established. Allocations were made to the respective proration units themselves, and not to the wells. Inasmuch as 40 acres became the established proration unit, spacing rules under such agreements took rudimentary form—no well was permitted to be drilled closer than 330 ft. of the exterior boundary of the operator's property line. The practice is still in effect.

In the early history of proration the question was at once presented as to what basis should allocations be made to the respective proration units capable of producing the allowable; i.e., should allocations be made upon potential, static bottom-hole pressure, or simply a flat allowable for each 40-acre proration unit, regardless of the other two factors just mentioned. At first, potential was the major factor, with the flat allowable to the proration unit the minor factor.

Under the early proration agreements for the Hobbs field, allocations to the respective 40-acre units capable of making the allowable were based upon a 75 per cent potential factor and a 25 per cent flat allowable to the proration unit, regardless of its ability to produce.

Under the proration agreement of the old Maljamar-Grayburg area (Eddy and Lea counties) as the limits of said area were then described, a flat 25-bbl. allocation was assigned to each proration unit capable of producing that amount, plus an allocation above that amount based on potential. The same was true of the succeeding Artesia-Grayburg-Jackson-Maljamar area (Eddy and Lea counties). "Proration plan order," covering somewhat the same general area, promulgated during the first year of the Oil Conservation Commission, but differing by a slight innovation whereby 1 bbl. for each 100 ft. in excess of 2,500 ft. of well depth was added to the 25-bbl. flat-allowable-per-proration unit. Later, but still in the early period of the commission, the Hobbs proration agreement order lessened the potential factor and increased by 60 per cent the flat-allowable-to-the-proration unit. However, potential as a norm in making allocations ultimately was discarded altogether, inasmuch as production in the chief producing region was predominately from limestone—a well producing from a limestone horizon with comparatively low initial potential often could have its potential materially increased and sometimes could be stepped up into a "big" well simply by acidizing.

The value of bottom-hole pressure as an allocation factor was recognized in the Hobbs and Monument fields. The allocations for the various proration units within the Monument field were made upon a 20 per cent "static bottom-hole pressure factor" and an 80 per cent flat allowable.

Within more immediate times the existing Hobbs proration order was devised upon the basis of adjusting the potential factor by bottom-hole pressure.

North Dakota

North Dakota is an example of a present non-oil-producing state that has taken steps to prepare for proper future oil development. In 1941 the state legislature passed an oil and gas conservation measure. Subsequent to the passage of the bill, the Industrial Commission adopted rules and regulations that have been amended only slightly from the rules suggested by the Interstate Oil Compact Commission. The amendments were necessary to make the rules applicable to North Dakota conditions.

Here is an instance where the Interstate Oil Compact Commission has been of service to a state in preparing for oil and gas development.

Ohio

Conservation laws of Ohio are administered by the Department of Industrial Relations, Division of Mines, under a chief who appoints an oil and

SOMASTIC

Laying SOMASTIC *Coated Pipe*

Permanent Pipe Protection

Steel is conserved **by limiting the wall thickness of steel pipe to the minimum required by line operating pressures** ***and applying*** **SOMASTIC** ***Pipe Coating to permanently preverve the original wall thickness of the pipe.***

PORTABLE PLANTS
AVAILABLE EVERYWHERE

SOMASTIC
REG. U. S. PAT. OFF.
PIPE COATING

INDUSTRIAL ENGINEERING CO.

WILMINGTON, CALIFORNIA, Box 457 **HOUSTON, TEXAS, Box 2091** **BARTLESVILLE, OKLAHOMA, Box 149**

gas-well inspector. The granting of drilling permits is supervised by the oil and gas-well inspector. Well logs must be filed with the Division of Mines. Notices of well abandonments must be filed, and detailed reports must be filed after the work has been completed.

A bill legalizing flooding of oil sands was passed by the Ohio Legislature in 1939.

Oklahoma

Oklahoma is the pioneer among oil-producing states in adopting conservation and proration legislation and regulation. Oklahoma also furthered the organization of the Interstate Oil Compact Commission, and the headquarters of the Compact Commission has been maintained in the state Capitol Building in Oklahoma City since the inception of the compact.

Although recently discovered fields with flush production have been small in extent, efforts have been made by the Oklahoma Oil and Gas Conservation Department to enlist the operators to enter into cooperative engineering studies of the field reservoirs to determine the feasibility of gas reinjection, and to establish production rates and gas-oil-ratio control that will result in maximum recovery. The engineering-committee organizations that have operated in the Billings and Burbank pools are outstanding examples of cooperative enterprises that have facilitated the pressure-maintenance programs in these fields. In the East Cromwell field cooperative efforts have curtailed gas wastage by the installation of packers. At the present time an engineering committee in the Apache pool is studying the feasibility of returning gas to the reservoir, but the shortage of critical materials has hampered efforts to establish a gas-reinjection program.

Efforts will be made to obtain more engineering personnel and equipment to make studies and check the operation of reservoir energy in other producing areas. The Oklahoma Corporation Commission, through its Oil and Gas Conservation Department, has enjoyed close cooperation with the oil and gas industry. A round-table discussion of all oil and gas matters in the state is held each month prior to the market-demand hearing.

South Dakota

South Dakota is another state that has prepared for oil and gas development. No oil production has been discovered, but shallow gas production has been developed and produced since 1899.

The South Dakota Legislative Assembly passed an oil and gas conservation law which was approved by Governor Bushfield on March 11, 1941. This law established a state Oil and Gas Board, composed of the governor, the attorney general, and the state engineer, with the state geologist acting as a technical advisor. The law requires a fee of $25 for a permit to drill oil and gas wells. The filing of logs, drilling records, and formation samples and cores is required within 6 months after the completion date of any well.

Texas

With more than 731 oil fields and approximately 522 gas fields in 145 counties, Texas has many diverse and complex problems in oil and gas conservation. The Railroad Commission of Texas in 1928 promulgated orders for the first proration of oil production in the Winkler County pool. However, these orders were enjoined in December 1928.

A state-wide program of proration was put in effect on August 27, 1930, and the Railroad Commission has kept in force continuously a state-wide program of conservation. Only two lawsuits were filed prior to the discovery of the great East Texas field.

Special and unusual difficulties were encountered in dealing with the East Texas situation due to the size of the field and to the large number of small ownerships. The Railroad Commission has been criticized for granting exceptions to Rule 37 in the East Texas field. Those who advance this criticism forget the fact that Rule 37 was sustained by the courts solely upon the ground that exceptions were authorized when necessary to protect vested property rights. No court has held that Rule 37 would be valid if enforced in such a way as to deny to the owner of a small tract the right to drill on his land. To sustain the validity of the rule, the Railroad Commission was compelled to grant exceptions to it. A large number was granted in the East Texas field.

In the period from the early part of 1931 to November 1932, the Railroad Commission suffered from a hundred or more lawsuits and injunctions and adverse court decisions, and inadequate legislation until the legislature passed the present "market demand" law under which the Railroad Commission now is enforcing proration in Texas. The Railroad Commission was compelled to proceed with its attempts to enforce proration unaided by the market-demand legislation for more than 4 years, and it was compelled to deal with the East Texas situation for nearly 2 years unaided by such legislation.

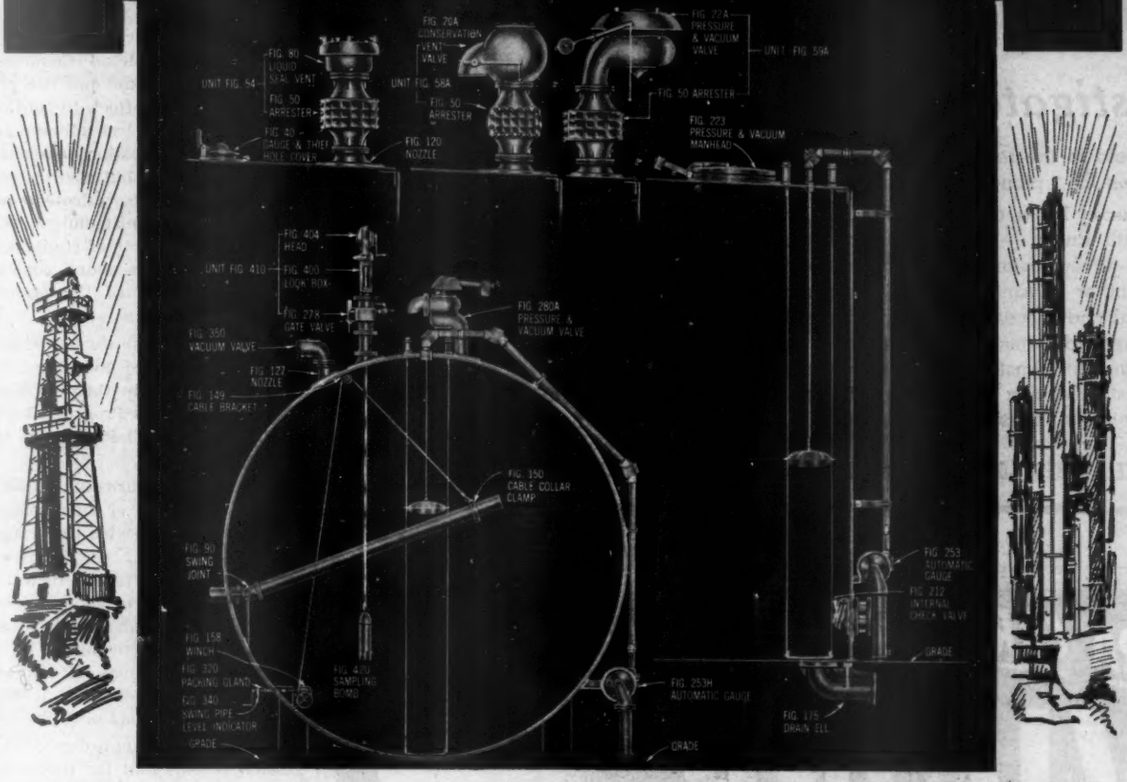
Three days after the law had become effective on November 12, 1932, the Railroad Commission held a state-wide hearing and issued appropriate orders. Further hearings amended the orders to meet attacks on their validity. More than 60 federal court suits were filed against the orders.

At every Railroad Commission hearing dealing with the East Texas field, the members of the commission publicly have invited definite concrete suggestions from the producers regarding proper and legal plans of enforcing proration in East Texas. The attorney general and his assistants have made extensive studies of these difficulties, and everything has been done that could

LUBRICANT OR FUEL
YOUR HEATER DETERMINES RESULTS

THERE are all types of installations, for all types of products, for many varying conditions. Only experience can assure selection of the proper heater. Only sound engineering can help you secure most profitable results. Alcorn has had eighteen years' experience covering the industry's most vital changes. Alcorn has served the largest companies, and also the smallest units.

ALCORN COMBUSTION COMPANY
SCHAFF BLDG., PHILADELPHIA
LOS ANGELES HOUSTON SAN FRANCISCO



..have your 'Volatiles' gone A.W.O.L.?

In Pipe Line Terminals, Oil Fields and Refineries, "VAREC" approved Vapor Recovery and Tank Equipment prevents evaporation losses and safely controls highly combustible gases from critical War-time Products as Butadiene, Butane, Toluol, Toluene, and High Octane Aviation Gasoline.

Petroleum engineers specify "VAREC" equipment STANDARD for the handling of all toxic and combustible gases, economically and efficiently. "VAREC" Laboratory and Engineering Departments will collaborate with you on all gas venting problems.

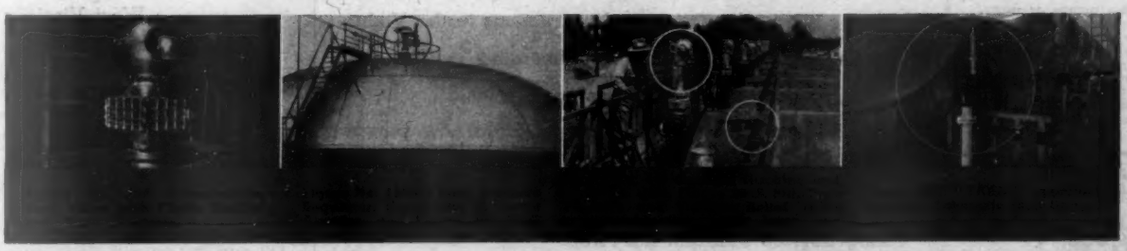
The New "VAREC" Tank Equipment Gas Control and Safety Devices Catalog and Handbook, P-7, will soon be off the press. Profusely illustrated with flow diagrams, service installations, product descriptions, and engineering data, it is a valuable asset to your library.

THE VAPOR RECOVERY SYSTEMS COMPANY

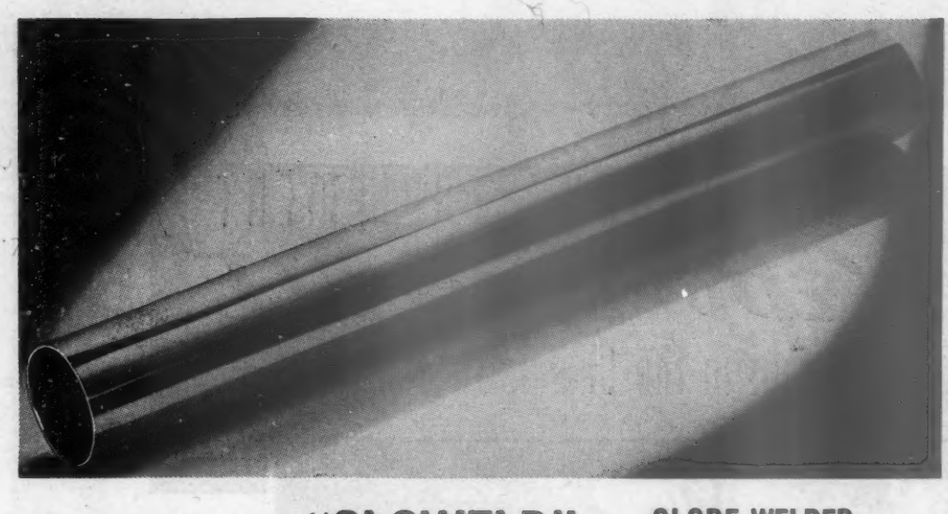
The Pace-Setter Since 1928

Branch Offices and Stocks carried at
New York City - Houston, Texas - Tulsa, Oklahoma
Agencies Everywhere

"VAREC" APPROVED INSTALLATIONS THE WORLD OVER



THE PACE SETTER SINCE 1928



Investigate "GLOWELD" GLOBE WELDED STAINLESS STEEL TUBING

. . . Gloweld is the result of a long period of research and experiment by the Globe Steel Tubes Co., pioneer manufacturer of stainless steel tubing.

It is produced by a closely controlled electric welding process that gives it unusually smooth finish — "flash" is hardly detectable. Gloweld's light weight, high resistance to corrosion, heat and pressure, comparatively lower cost, and other advantages will find many applications for tubing in chemical and process industries, food industries, pulp and paper, oil and other industries where these factors are needed. It is already in use in aircraft construction — as hydraulic lines, and for engine parts. Available in a wide range of diameters and wall sizes, in practically all stainless steel analyses. Write for full information.

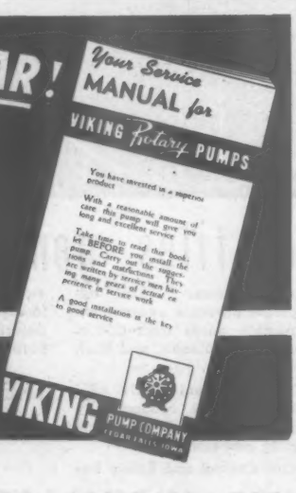
GLOBE STEEL TUBES CO., 4011 W. Burnham St., MILWAUKEE, WISCONSIN

GLOBE TUBES

EXTRA CARE Gives EXTRA WEAR!

VIKING Service Manual

.... WILL HELP YOU "KEEP 'EM PUMPING"!



Please... DON'T FORGET

When ordering pumps or parts, it is necessary that you give us your priority rating and allocation symbol. Be sure to obtain the highest rating possible. Priority regulations are changed frequently. Check up to see if changes made improve your rating. Thank you.

Many years of experience have produced the helpful, money-saving information and instructions in the Viking Service Manual. It's a handy, illustrated booklet that gives you practical suggestions how to install, operate and maintain Viking Rotary Pumps. Right now pumps are hard to get. So it pays to give your pumps *extra* care to get *extra* wear. Write today for your copy of the Viking Service Manual. It's FREE.

VIKING PUMPS — FIRST IN AMERICA

VIKING Pump COMPANY CEDAR FALLS, IOWA

have been done to prepare proper and legal orders.

At the time the market-demand bill become effective, more than 9,000 oil wells had been drilled in the East Texas field. Each operator naturally desires to produce enough oil to pay at least for the cost of his well. As a practical matter, the Railroad Commission, therefore, has to deal with the natural desire of the individual operator to produce at least enough oil to return his well investment and the interests of the industry and the state as a whole. In other words, the Railroad Commission is attempting, as far as humanly possible, to avoid overproduction of oil—production beyond the market demand which the legislature had denounced as waste, and to maintain the vested property rights of the operator, already upheld by the federal courts, to produce at least enough oil to pay for his well. The federal court already has held that, although the Railroad Commission can curtail production, it cannot put the production so low as to amount, in effect, to confiscation. The Railroad Commission has adhered to the view that petroleum conservation involves not only engineering problems, but also the question of equity and property rights. Adequate conservation rules and regulations must embrace engineering principles and the rights of equity and property. The determination of a sound conservation program required a study of the entire petroleum industry.

The Railroad Commission in every instance has followed, and tried to follow, the recommendations as outlined in the American Petroleum Institute committee's Progress Report on Standards of Allocation of Oil Production Within Pools and Among Pools.

Every field in Texas is covered by rules, either by the state rules or rules adopted for the particular field. State-wide rules apply to every well drilled in Texas. After the first well has been completed in a particular field, the operator may request a hearing to adopt rules and regulations to suit that particular field. At such hearing the commission hears testimony as to spacing, proration units, methods of allocation, control of gas and water production, pressure maintenance and method of completing the wells.

A study of various orders of the Railroad Commission reveals that the recommendations in the progress report, previously cited, relative to field rules are being followed by the commission.

In 1940 and 1941 the Railroad Commission began a study of distributing the total state allowable among pools upon the types of crude produced. As a result of an extensive study and thorough analyses of more than 500 samples of crude, the Railroad Commission adopted the "yardstick formula." The purpose of the formula was to prevent selective purchasing by applying a plan which would take into consideration the quality of the crude, depth of production, attributable acreage, and other factors.

West Virginia

The Department of Mines supervises the drilling, casing, and plugging of oil and gas wells through its Oil and Gas Division. Especial attention is devoted to the protection of coal seams and mines. Gas wastage is prohibited. Every 3 months a detailed printed report is issued regarding well completions and abandonments.

Wyoming

Oil and gas conservation laws in Wyoming are administered by the state mineral supervisor, who is appointed by the commissioner of public lands with the approval of the governor. The mineral supervisor is required to visit all of the Wyoming proven oil and gas fields, several times a year, in assisting the operators in complying with the conservation regulations such as plugging of

wells, eliminating gas wastage, and proper completion and production methods. Well logs and other reports deemed necessary are required to be filed.

Other States

Colorado, Kentucky, Pennsylvania, and New York have no allocation rules. In Colorado the state oil and gas inspector and the Gas Conservation Commission have supervision of waste-prevention measures and the proper plugging and abandonment of wells. It has not been necessary to adopt allocation measures in Colorado. In Kentucky the Department of Mines supervises well plugging. An effort to pass a conservation law failed in 1940. New York and Pennsylvania have no regulatory agencies to supervise conservation of oil and gas. Early in 1942, a study was made to determine the feasibility of enacting a conservation law in New York.

Conclusion

In this war effort the Interstate Oil Compact Commission is firmly following its function of furthering the conservation of oil and gas. It has established organs of investigation and research to aid the states and other agencies in playing an important part in winning the war.

At the present time consideration is being given by the Interstate Oil Compact Commission to the feasibility and desirability of the preparation of a conservation or educational exhibit and program on the subject of oil and gas conservation. The real merit of the conservation program may be presented to legislative bodies, governmental officials and agencies, the industry, and general public by utilizing a comprehensive exhibit showing the whole range of the conservation movement. A missionary squadron of technical experts, each thoroughly trained in one phase of conservation, could present a factual survey, presentation of principles involved, benefits, and necessary facilities to accomplish a real conservation program.

The work of the Interstate Oil Compact Commission during the past 7 years fits in admirably with the all-out effort necessary in this war.

At the first meeting of the National Conference of Petroleum Regulatory Authorities in April 1942, Petroleum Coordinator Ickes emphasized the need for strong, active, effective conservation laws in each of the oil and gas-producing states. He further stated that it would please him personally to see each state adopt or revise and strengthen its conservation laws so that the end of the war would find the states so well equipped, and with such a successful record of cooperative accomplishment during the war, as to demonstrate fully that the states then could effect continued proper regulation of petroleum operations.

The Interstate Oil Compact Commission stands ready to assist in any possible way, and welcomes the cooperation and assistance of all branches of the oil and gas industry in solving the problems created by the war.

It is hoped that the states of California, Wyoming, Montana, Nebraska, Mississippi, Ohio, Indiana, and West Virginia will see fit to join this cooperative program with the 12 member states of the Interstate Oil Compact Commission.

●

Yates Field's Reserves High On Sixteenth Anniversary

Sixteenth anniversary of the Yates field, Pecos County, Texas, the birthplace of modern proration, passed late in October without particular notice although it did afford an opportunity to check production from a reservoir that has been under restraint most of its productive life.

The Yates field had produced 263,949,845 bbl. on its sixteenth birthday, October 27.

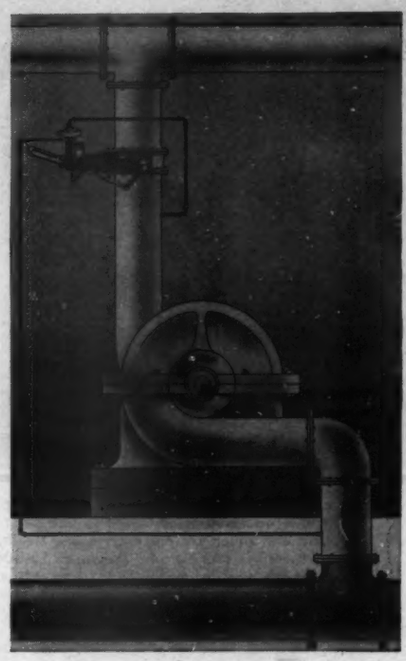
HOW TO PROTECT Pumping Units and Prevent Water Hammer

For example, with 55 p.s.i. in the common header and a 2 lb. lift, a differential control, utilizing the hydraulic cylinder, would be set for approximately 56 lbs. The Butterfly Valve remains open as long as a greater differential than 56 lbs. is maintained.

In case of pump or power failure, the flow through the pump reverses. The natural tendency of an R-S Valve is to close itself under a pressure drop. The differential now drops below 56 lbs. and the cylinder closes the valve wedge-tight. It will remain closed until the pressure differential is regained. When this takes place, the valve opens gradually and normal pumping operations are resumed.

Closing of the valve causes no water hammer since the valve can not move any faster than the bleeding of the cylinder discharge permits.

Declutching unit with self-locking hand wheel control also available for similar installations. Sizes to 84-inches. Suitable for high or low temperatures and pressures to 600 lbs. for the positive control and wedge-tight shut-off of liquids, gases and semi-solid materials.



A 125-lb. R-S Butterfly Valve, equipped with hydraulic cylinder for automatic operation, serves a triple purpose where a battery of pumps discharges into a common header. Prevents a synchronous-driven pump from grabbing all the load when the pump is started, prevents reverse flow through the pump and eliminates water hammer.

R-S

Write for Catalog No. 10-B

In the three-inch sizes and upward, chain wheel operation is desirable for inaccessible locations. Similar in all details to the hand wheel valves with the exception of the chain wheel which is mounted on the worm shaft in place of the hand wheel.

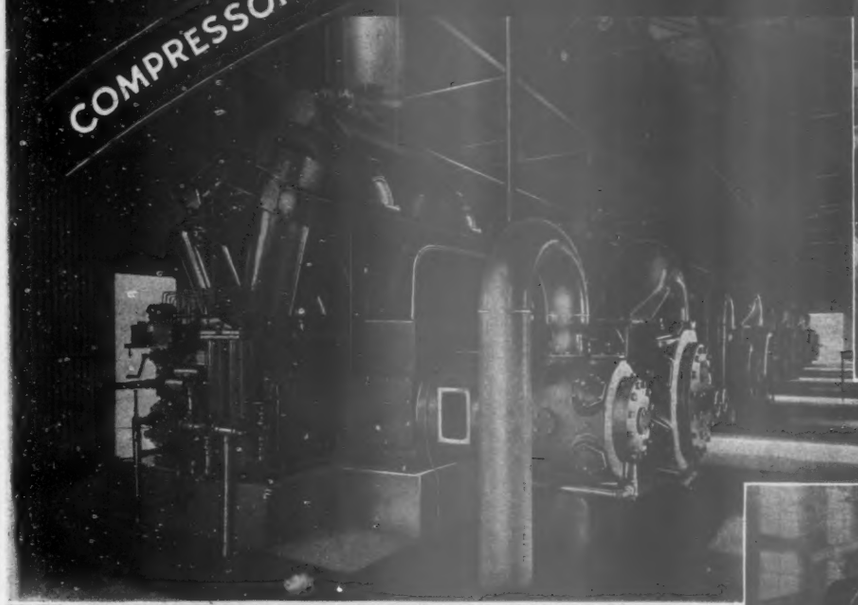
Used for the positive control and wedge-tight shut-off of any material that flows or is forced through a pipe.

R-S PRODUCTS CORPORATION, 4538 Germantown Ave., Philadelphia, Pa.

R-S Streamlined BUTTERFLY VALVES

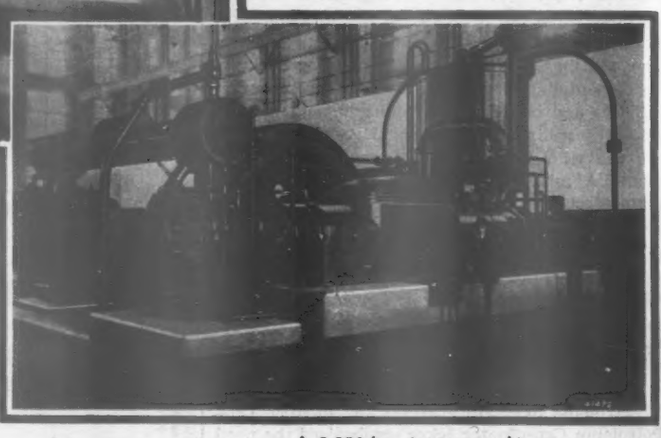
Ingersoll-Rand *Machinery*

COMPRESSORS



Five electric- and five steam-driven high-pressure compressors in a refinery.

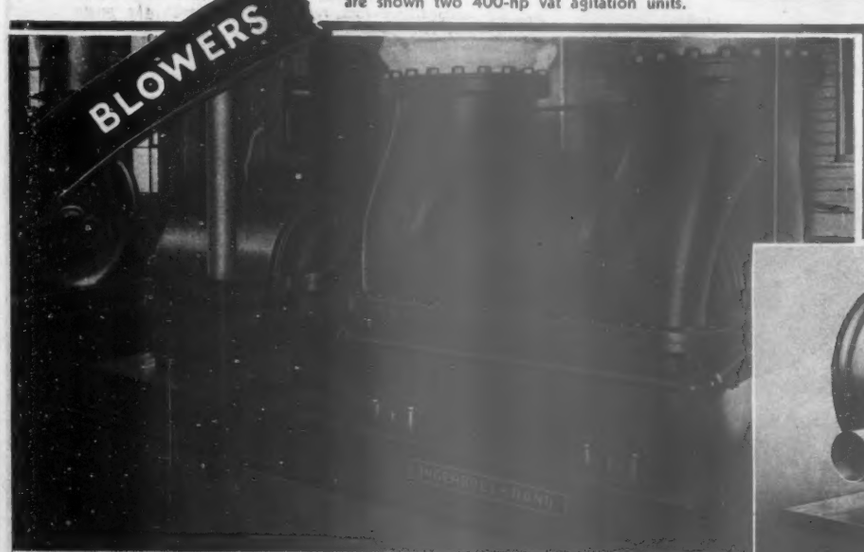
These gas-engine-driven units are compressing natural gas in Arkansas. Ingersoll-Rand compressors range in size from ¼ to 3000 horsepower . . . and are driven by electric motors, steam, oil engines, or gas engines. Pressures range from vacuum to 15,000 lb per sq in. Installations of high-pressure machines total more than 150,000 hp.



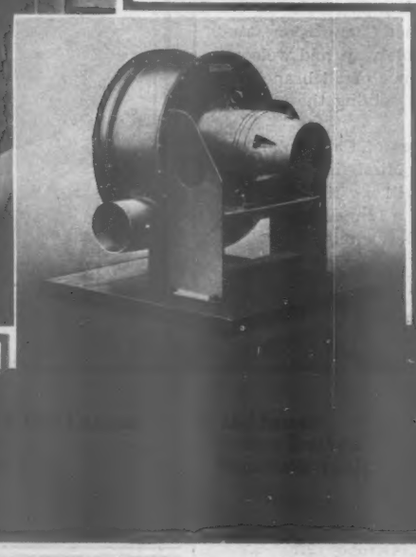
A 2,250-hp, six-stage machine compressing gas to 4,500 lb per sq in. pressure in a synthetic ammonia process.

BLOWERS

Blowers for air and many gases are available in sizes from 2 to 14,500 hp. At the left are shown two 400-hp vat agitation units.



A Type "G" MOTOR-BLOWER equipped with an explosion-proof motor for use in a munitions plant.



for Vital Processes

We don't profess to be experts on the many refinery and other chemical processes . . . because each process has its own specialists who know what they need and how to procure the best equipment for the job.

We have, however, earned the reputation of being experts in developing, manufacturing, and applying compressors, blowers, pumps, and vacuum equipment . . . machines that meet the rigid specifications of the process engineers, and that stand up under the operating conditions and continuous service required in recycling, gasoline extraction, and in the manufacture of aviation gasoline, synthetic rubber, synthetic ammonia, explosives, etc.

While new cycles or processes are still in the idea stage, our engineers are on the job with more than 50 years' experience in applying Ingersoll-Rand products to the problems of compression, pumping, vacuums, refrigeration, and condensation.

I-R heavy-duty machines are built and rated for continuous full-load operation, 24 hours a day, and they require only a minimum of time and money for inspection and repairs. And whenever new machines or new lines of equipment are developed specially for one industry or another, the keynote of I-R designers is flexibility and standardization of parts. Such a policy provides important advantages to every purchaser of Ingersoll-Rand equipment.

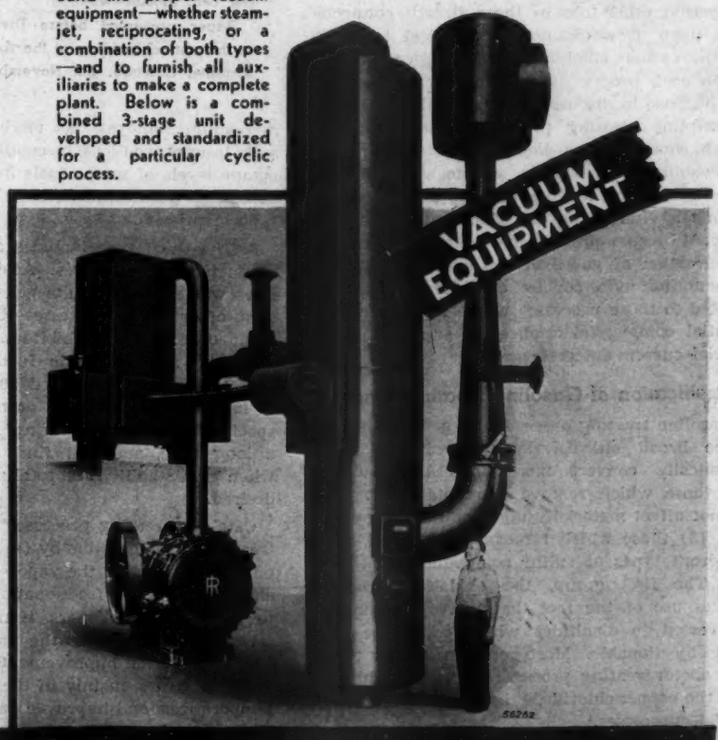
PUMPS

Below is a group of various types of Ingersoll-Rand refinery pumps. I-R pumps range in size from 5 to 100,000 gpm . . . for pressures up to 3,000 lb . . . temperatures up to 800°F . . . and can be built to handle practically any liquid.

Above are shown several Motorpumps—the versatile little units that have a million uses.

VACUUM EQUIPMENT

Ingersoll-Rand is in a position to recommend and build the proper vacuum equipment—whether steam-jet, reciprocating, or a combination of both types—and to furnish all auxiliaries to make a complete plant. Below is a combined 3-stage unit developed and standardized for a particular cyclic process.



Critical Analysis of Sweetening Processes And Mercaptan Removal

By JOHN HAPPEL, S. P. CAULEY, and H. S. KELLY
Technical Service Division, Socony-Vacuum Oil Co., Inc.
Brooklyn, N. Y.

A. P. I.

Factors affecting the applicability of the various treating processes are discussed. A simplified equation for the calculation of mercaptan removal with caustic solutions, with or without solubility promoters, is presented. Data on the extraction and stripping coefficients obtainable with natural solubility promoters extracted by caustic washing cracked and straightrun gasoline from Mid-Continent crude are given. Curves showing how the final mercaptan content affects the net treating cost in the Shell Solutizer process and in caustic washing are given. The net costs (including TEL* credit based on raw gasoline) when treating to 0.002 to 0.003 per cent final mercaptan-sulfur content may be one-third less than when mercaptans are removed down to 0.0004 per cent (doctor-sweet).

Paper presented before Division of Refining at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

IN recent years requirements for higher octane-number gasolines and a better understanding of the factors which influence gasoline quality have caused doctor sweetening to be viewed in a more critical light, and have resulted in the development of other methods for accomplishing mercaptan conversion or the removal of mercaptans from gasoline. More recently the national emergency, and diversion of some high-octane-base stocks formerly used in motor to aviation-grade fuels, as blending stocks, have caused refiners to be more critical of those processes which use vital chemicals and which do not add to the quality of the product.

The applicability of a given treating process depends upon a number of factors, some of which may vary appreciably in individual cases. Also, because a number of the newer processes have not had sufficient application for complete evaluation, other than by those directly connected with them, it would not be practical for us to list the various combinations of these factors for which each process is superior. It is, therefore, our purpose to discuss briefly the different types of gasoline treating processes and the factors which should be considered in determining the applicability of a process, and to show the saving—both in cost and in consumption of strategic chemicals vital to the war effort—which could be effected by changing the mercaptan-sulfur-content specification of gasoline. In order to make our presentation more concise, consideration has been limited to those processes which have found substantial commercial application or which are of special current interest.

Classification of Gasoline-Treating Processes

Gasoline treating processes, in general, fall into three broad classifications: (1) Those which chemically convert mercaptans to disulfides; (2) those which remove mercaptans but which do not affect materially other sulfur compounds; and (3) those which remove some or all of the different types of sulfur compounds.

1. The first group, the oxidation processes, makes use of the fact that mercaptans may be converted to disulfides whose odors are much less objectionable. Most common of this type is the doctor-treating process.[1,9] Others of this type are the copper-chloride,[2,12] hypochlorite,[1] and lead-sulfide processes.[1]

2. Processes representative of the second type, currently being given most consideration, are caustic scrubbing,[1,23,29,34,36] the Shell Solutizer process,[14] and the Atlantic Unisol process.[3] The latter two processes depend upon the addition of certain compounds to increase the solubility of mercaptans in caustic solutions. Natural solubility promoters are sometimes present in naphthas, and these tend to build up in the caustic scrubbing solution—with resultant beneficial effects on mercaptan removal. As mercaptan removal results in improved lead susceptibility, the increased octane levels of motor fuels in recent years have caused the greatest attention to be focused on this type of process.

3. The third type includes acid, clay, and catalytic treating processes. Acid treating[1] of gasolines was practiced quite generally after the advent of cracking processes—before the development of oxidation inhibitors. It is sufficiently well known to preclude further discussion—except to say that it is used only when necessary to improve gum stability or to meet total sulfur specifications. Clay treating has been used for a long time, and still finds many applications when gum stability and total sulfur reduction are desired.

Catalytic treating processes[4,27,30] usually involve treating of the gasoline by (*a*) Vaporization of the oil; (*b*) passing of the vapors through a catalyst chamber; and (*c*) fractionation of the treated oil to remove the polymers, if necessary. Some reforming may occur at the reaction temperature. There have been improvements in these processes in recent years, mainly in the direction of higher temperatures and improved catalysts, and a number of commercial installations have been made. However, inasmuch as it is the purpose of this paper to review those processes concerned with sweetening and mercaptan removal, no detailed consideration will be given to the total desulfurization processes.

Table 1 gives a comparison of the important features of the more common processes of each of the types just described. Many variations of these processes are practiced commercially. Naturally, we do not claim that every modification is listed; rather it is intended that the tabulation shall give a general picture of the various processes.

Any comparison of the applicability of several treating processes to a given problem should consider the following factors as of prime importance: (1) The specifications of the product; (2) the physical properties of the gasoline to be treated; (3) the characteristics of the various processes themselves; and (4) their relative economics. Finally, the importance of flexibility to meet changes in specifications, in crude source, or in processing should not be overlooked.

Specifications

The specifications of finished gasoline which have the most direct bearing on the type of treating process to be used are: (1) Octane number; and (2) mercaptan content. Other specifications of lesser importance include total sulfur content, copper-dish gum, and A.S.T.M. gum test.

The mercaptan content of treated gasoline in the past always has been specified by the doctor test, which requires that the mercaptan content be at or below 0.0004 per cent by weight of mercaptan sulfur.[26] Recently it has been pointed out that this test is far too rigorous.[3,35] Gasolines now are being marketed with a mercaptan-sulfur content up to 0.005 per cent and higher. Some reasons for this, not discussed by Happel and Cauley,[35] are given in connection with the Shell Solutizer process and caustic washing.

With any particular gasoline, the octane-number specification determines the level to which the gasoline must be leaded. With gasolines requiring a large amount of tetraethyl lead, the mercaptan-removal processes are at a premium.

Occasionally total sulfur or gum requirements demand the use of one of the Type 3 processes (Table 1). However, with oxidation inhibitors and blending with low sulfur stocks, this necessity occurs infrequently.

Physical Properties of the Raw Gasoline

Most important of the physical properties of a raw gasoline, in our opinion, are: (1) Total mercaptan-sulfur content; (2) mercaptan distribution. The total mercaptan content is a consideration in all processes; its distribution affects the case of removal by Type 2 process (Table 1).

Depending upon the type of crude and of its processing, a wide variation in mercaptan content and mercaptan distribution is possible. Table 2 gives some amounts and distributions for typical stocks. Cracked gasolines usually contain a higher proportion of low-molecular-weight mercaptans as compared with straightrun naphthas of the same boiling range. In addition, the total mercaptan content of catalytically cracked gasoline is usually low.

The mercaptan distribution may be determined by fractionation of the gasoline as described by Happel and Robertson.[24] A further refinement for analysis of the C_6+ mercaptans is caustic washing to determine the thiophenol content. It has been noticed that the mercaptan content of sour gasoline often decreases considerably during storage or shipment. Shipment in glass containers, and addition of about 0.5 lb. of alpha naphthol per 10,000 gal. of gasoline, prevent oxidation of the mercaptans when considerable time must elapse between sampling and analysis, as in a gasoline survey undertaken by a large refiner.

The organic-acid content affects the gum-stability properties of the gasoline, and may cause fouling of alkaline treating reagents. The effect of organic acids on caustic scrubbing is discussed in the following section of this paper.

The influence of the octane number, and of

*Tetraethyl lead.

TABLE 1—CLASSIFICATION OF GASOLINE-TREATING PROCESSES

Process	Chemicals used	Sweetening reaction	Complete sweetening effect	Regeneration of treating solution—chemical reaction	Can it be controlled to a mercaptan-sulfur specification	Life of treating reagent	Operating Temperatures and pressures
Type 1							
Doctor	NaOH, PbO, S[10]	$2RSH+Na_2PbO_2+S=PbS+RSSR+2NaOH$[1]	Yes[1]	Air blowing at 160° to 190° F.[1 20]	No	2 to 6 months	Temperature, 65° to 100° F.[9] Pressure, atmospheric
Lead sulfide	PbS, NaOH[1]	Many variations[1]	Yes[1]	.....	No	.....	Temperature and pressure are both at atmospheric conditions
Hypochlorite	NaOCl or $Ca(OCl)_2$[12]	$2RSH+NaOCl=RSSR+H_2O+NaCl$[1 19] RSH converted to water-soluble sulfones and sulfoxides	Yes[13]	Not regenerated	No	.....	Temperature and pressure are both at atmospheric conditions[1 9]
Copper processes:							
Liquid	$CuCl_2$	$2CuCl_2+2RSH=2CuCl+RSSR+2HCl$[13]	Yes[13]	CuCl solution is blown with air at atmospheric temperature. $2CuCl+2HCl+½O_2=2CuCl+H_2O$[13]	No	.....	Temperature and pressure are both at atmospheric conditions[13]
Bed	$CuCl_2$	Same as above	Yes[13]	Regenerated in place with atmospheric or pure oxygen[13] Same equation as above	No	.....	Temperature and pressure are both at atmospheric conditions[13]
Slurry	$CuCl_2$, clay	$2CuCl_2+2RSH=2CuCl+RSSR+2HCl$[5]	Yes[5]	Regenerated in place with pure oxygen[5] Same equation as above	No	1 to 2 months[5]	Temperature and pressure are both at atmospheric conditions[5]
Type 2							
Caustic scrubbing	NaOH[19]	RSH dissolved in treating solution[19]	Depends upon stock[12]	Steam stripping of treating solution[19]	Yes	.....	Temperature and pressure are both at atmospheric conditions[19]
Shell Solutizer	KOH, isobutyric acid[14]	RSH dissolved in treating solution[14 18]	Yes[14]	Steam stripping of treating solution[14 15]	Yes	3 years	Temperature and pressure are both at atmospheric conditions[14]
Unisol	NaOH methanol[3]	RSH dissolved in treating solution[3]	Borderline[3]	Distilling methanol and mercaptans from caustic, and separating alcohol and mercaptans	No	Based on loss 0.004 per cent methanol in gasoline[3]	Temperature and pressure are both at atmospheric conditions[3]
Type 3							
Sulfuric acid	H_2SO_4[1]	RSH converted to disulfides which are soluble in the sulfuric acid[1]	Depends upon stock[1]	.....	No	.....	Temperature, atmospheric or colder.[1] Presure, atmospheric
Gray catalytic desulfurization	Clay[17]	Sulfur compounds converted to H_2S, which is removed by caustic washing or stabilization[17]	Depends upon stock[17]	Not necessary	No	About 5,000 bbl. gasoline per ton of clay[17]	Temperature, about 700° F. Pressure, moderate[17]
Houdry catalytic treating	Special catalyst[22]	Sulfur compounds removed to H_2S, which is removed catalyst[22]	Depends upon stock	Air blowing at 700° F.[22]	No	.....	Temperature, 645° F.[22]
Perco	Bauxite[4]	Sulfur compounds converted to H_2S, which is removed from gasoline[14 6]	Depends upon stock[6]	Burning in atmosphere of controlled oxygen content[6]	No	2,500 bbl. to 5,000 bbl. of gasoline per ton of catalyst without regeneration	Temperature, 700° to 750° F.[1] Presure, 20 to 30 lb. per sq. in.[6]

*Finds main use in treating natural fasoline.[1]

TABLE 2—MERCAPTAN DISTRIBUTION OF SOME TYPICAL GASOLINES

Gasoline	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Type	Straight-run	Poly-form	Coking unit	Controlled coil cracking unit			Houdry	Straight-run	Houdry	Straight-run	Vapor-phase	Houdry	Straight-run	Thermal cracked	Thermal cracked	Vapor-phase
				Synthetic charge	Crude charge	Crude charge										
Crude	Mid-Continent							Kansas		Mid-Continent					East Texas	
Boiling range, °F.	100-275	100-400	100-400	100-400	100-400	100-400	100-400	100-300	100-400	100-400	100-400	100-400	100-400	100-400	100-400	100-400
Per cent of total mercaptan content:																
Methyl	3.9	16.5	12.4	6.4	13.1	} 34.2	16.0	8.5	3.4	21.3	35.6	} 58.1	3.1	18.6	15.1	13.4
Ethyl	15.7	30.8	21.9	10.9	21.9		17.0	6.7	6.5	7.1	29.1		5.3	33.7	15.8	23.4
Propyl	30.6	29.0	24.9	13.4	20.0	21.2	8.0	11.5	5.3	11.0	9.3	11.3	10.0	10.9	19.7	19.8
Butyl	45.2	9.6	23.6	6.2	15.6	14.2	8.0	17.7	3.5	11.3	7.0	7.4	16.0	14.8	14.9	10.4
Amyl	4.6	9.4	15.6	11.1	10.9	11.8	8.0	55.6	5.8	10.5	4.6	3.1	12.2	9.5	6.9	6.8
Thiophenols	..	} 4.7	1.6	0.0	} 18.5	.	} 43.0	...	61.7	} 38.7	14.4	20.1	8.2	} 12.5	27.5	26.2
Hexyl and heavier	...			43.7		18.6		...	13.8				45.2			
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mercaptan sulfur in sample, per cent by weight	0.009	0.080	0.090	0.006	0.020	0.018	0.0090	0.0099	0.0117	0.0093	0.0314	0.0089	0.0078	0.020	0.635	0.020

TABLE 3—EFFECT OF TREATING PROCESSES UPON PHYSICAL PROPERTIES OF GASOLINE

Process—	Octane No.	TEL susceptibility	Inhibitor susceptibility	Total sulfur	Doctor test of treated gasoline	Gum content	Remarks
Doctor	Decreases[9 11]	Decrease or no change[9 11]	Decreases or no change[9 21]	Increases[1]	Sweet	.....	.....
Copper	No change[5 13]	No change[5 13]	Good[13 21]	No change[5 13]	Sweet[5 13]	No change[5 13]	Large increase in inhibitor requirement if any copper remains in gasoline[5]
Hypochlorite	Decreases[10]	Decreases[10]	Poor[10]	May be decreased[1]	Sweet[1]	Increases[1]	.....
RSH removal	Increase[2 3 8 11]	Increases[2 3 8 11 18]	Good[7 21]	Decreases[2 3 14]	Can be controlled	No change[7]	Alkyl-phenol content of treated gasoline must be controlled[7]
Catalytic and total sulfur removal	Increases[6 7 11] Decreases on acid treating[12]	Increases[6 11 17 18]	Good[17 22]	Decreases[1 6 17]	Depends upon stock[1 6 17]	Decreases[1 23]	.....

the total sulfur and oxidation stability, of a gasoline have been mentioned under "specifications."

Characteristics of the Various Processes

The general effects of the various treating processes on the physical properties of a gasoline are fairly well known, but for easy reference are given in Table 3.

Regenerated caustic washing and the Shell Solutizer process.

The work of Happel[24] and Yabroff[14 15 16 25] has shown the importance of the molecular weight of a mercaptan with regard to its ease of extraction with caustic solutions. Yabroff[25] has presented a method for calculation of the amount of mercaptan removal by any given set of conditions. A somewhat simpler formula, similar to the Kremser equation[26] in gas absorption, has been derived. The equation holds for each mercaptan present in the gasoline; it is as follows:

$$\text{Per cent } RSH \text{ left in gasoline} = 100\left[\frac{(1-S)(E^a-E)V + (E-1)(S-S^b)K_q}{(1-S)(E^a-E)V + (E^a-1)(S-S^b)K_q}\right] \quad (1)$$

Where:

$S = WK_s$, stripping factor.

W = steam : caustic ratio by volume; steam volume = condensate volume.

K_s = stripping coefficient.

$E = \frac{K_q}{V}$, extraction factor.

V = gasoline : caustic ratio by volume.

K_q = extraction coefficient.

a = number of theoretical extraction stages plus one.

b = number of theoretical regeneration stages plus one.

Inspection of Equation 1 shows that the characteristics of a treating solution which affect its ability to remove mercaptans from gasoline are its extraction and stripping coefficients.

Although the buildup of natural organic acids in caustic washing solutions has been noticed for years,[20 29 31] the importance of this buildup to the extraction and stripping coefficients of the caustic has been recognized only recently. These coefficients, K_q and K_s, are plotted in Figs. 1 and 2 against the number of carbon atoms in the normal mercaptans for a 10 per cent sodium-hydroxide solution, a 30 per cent sodium-hydroxide solution which had picked up 20 per cent by volume of "organic acids" while cracked and straightrun gasolines from Mid-Continent crude were being washed, and one of the Shell Solutizer solutions, K-2, which is 6N potassium hydroxide and 3N potassium isobutyrate. Organic-acid content was determined by neutralization with hydrochloric acid and measurement of the volume of the acidic layer liberated. Organic acids present in gasolines are both of the phenolic type[32] and aliphatic type.[27]

The inability of plain caustic solutions to remove the heavy mercaptans is evidenced by the solution's low extraction coefficient for such mercaptans. The higher extraction coefficients of the caustic solution which had picked up natural-mercaptan solubility promoters, particularly in the region of the high-molecular-weight mercaptans, remove this limitation from caustic washing. The still higher extraction coefficients of

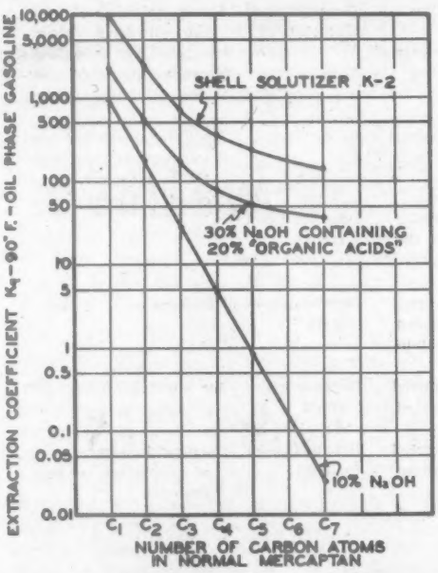


Fig. 1—Plot of extraction coefficient vs. number of carbon atoms in the normal mercaptan for some treating solutions

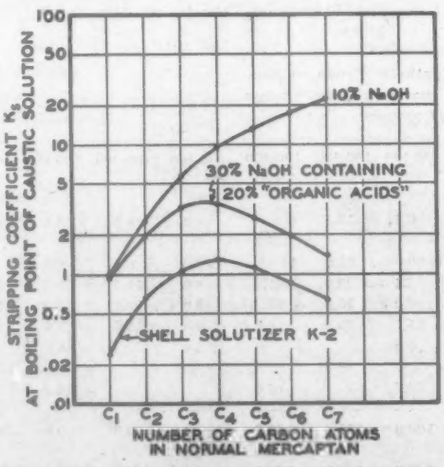


Fig. 2—Plot of stripping coefficient vs. number of carbon atoms in the normal mercaptan for some treating solutions

the K-2 Shell Solutizer solution are valuable particularly when the total mercaptan content is high or when treating to very low mercaptan contents; however, the smaller values of its stripping coefficients partly offset this.

The mercaptan distribution of the gasoline being treated affects the mercaptan removal obtained under any given set of conditions. Thus, cracked gasoline containing a higher proportion of light mercaptans is more responsive to the foregoing methods of mercaptan removal than a straightrun gasoline.

Equation 1 has been used to calculate the mercaptan removals which can be obtained by the treatment of two gasolines with a 10 per cent sodium hydroxide and a 30 per cent sodium-hydroxide solution containing 20 per cent organic acids extracted from cracked and straightrun gasoline from Mid-Continent crude. One gasoline was typical of straightrun gasolines in that it contained a predominance of heavy mercaptans, whereas the other was typical of cracked gasolines in that it contained chiefly low-molecular-weight mercaptans. Mercaptan distributions of these gasolines are shown in Table 4. For purposes of comparison, the same circulation rate of caustic (15 per cent of the gasoline volume) and the same amounts of stripping steam (10 lb. and 20 lb. per bbl. of gasoline) were used. A treating plant consisting of three mixing stages for caustic and gasoline, equaling two theoretical extraction stages and a seven-plate regeneration tower, giving three theoretical plates, was assumed.

TABLE 4—TYPICAL MERCAPTAN DISTRIBUTION OF RAW GASOLINES FROM MID-CONTINENT CRUDE

	Per cent of total mercaptan content	
Mercaptan—	Typical straightrun gasoline	Typical cracked gasoline
Methyl	4	19
Ethyl	6	34
Propyl	13	18
Butyl	19	15
Amyl	18	9
Hexyl (assumed heptyl)	40	5
Total	100	100
Total mercaptan-sulfur content, per cent by weight	0.0265	0.0357

Calculated mercaptan-sulfur contents of the treated gasolines are shown in Table 5.

Inspection of the data in Table 5 shows that 10 lb. per bbl. of stripping steam reduces the mercaptan content of the straightrun gasoline 81.9 per cent when the 30 per cent sodium-hydroxide solution containing 20 per cent organic acids is circulated. An additional 10 lb. per bbl. of steam removes only 10.2 per cent more. If the cracked

Modern ENGINEERING FOR *Modern* PRODUCTS AND PROCESSES

Today, more than ever before, refiners are depending on specialists for up-to-date information and technical data on new developments in all modern processes and products.

The McKee organization has rendered this service to refiners for many years.

McKee refinery specialists can fulfill your requirements on any or all phases of engineering and construction of your plant.

Products and Processes for which McKee engineering and construction services are available:

- Toluene
- Butadiene
- Alkylation
- Catalytic Cracking
- Isomerization
- Gas Concentration
- Hydrogenation
- Dehydrogenation
- Petroleum Synthetics

Arthur G. McKee & Company

★ *Engineers and Contractors* ★

2300 CHESTER AVENUE • CLEVELAND, OHIO

TABLE 5—EFFECT OF CAUSTIC WASHING ON GASOLINES IN TABLE 4

Treating solution—	Operating conditions	Mercaptan-sulfur contents (per cent) Straightrun gasoline Before	Straightrun gasoline After (calculated)	Cracked gasoline Before	Cracked gasoline After (calculated)
10 per cent sodium hydroxide	Treating-solution circulation rate: 15 per cent of gasoline volume Stripping steam: 10 lb. per bbl. of gasoline	0.0265	0.0173	0.0357	0.0083
30 per cent sodium hydroxide containing 20 per cent of organic acids	Same as above	0.0265	0.0050	0.0357	0.0020
10 per cent sodium hydroxide	Treating-solution circulation rate: 15 per cent of gasoline volume Stripping steam: 20 lb. per bbl. of gasoline	0.0265	0.0172	0.0357	0.0076
30 per cent sodium hydroxide containing 20 per cent of organic acids	Same as above	0.0265	0.0023	0.0357	0.0008

TALK TO Anchor ABOUT
BUTANE-PROPANE
If you Sell—
Get in touch with us if you have butane or propane to sell. We can offer a profitable market outlet for you. We contract to purchase your entire plant production.
If you Buy—
Let us supply your needs for butane or propane for aviation gasoline, synthetic rubber plant, or industrial use. We can ship from one of our many plants. Prompt deliveries in Anchor tank cars or large transports.
We buy — we sell — we manufacture
BUTANE AND PROPANE
Anchorgas
ANCHOR
PETROLEUM COMPANY
Atlas Life Bldg. Tulsa, Okla.

gasoline is treated, the same solution removes 94.4 per cent of the mercaptans with 10 lb. per bbl. of steam, and only 3.5 per cent more when the steam rate is increased to 20 lb. per bbl. The additional mercaptan removal obtained by increasing the steam rate from 10 to 20 lb. per bbl. is even less in each case when the 10 per cent sodium hydroxide is circulated.

More complete data, showing the effect of increased final mercaptan content on stripping-steam requirements when the Shell Solutizer process is used, have been supplied by Shell Development Co. Thse data are presented in Table 6.

Inspection of the data in Table 6 shows that the stripping-steam requirement rises sharply when washing to very low mercaptan contents. Also it will be noted that the recommended caustic circulation rate increases when washing to low final mercaptan contents, and when gasolines containing a high proportion of heavy mercaptans are treated, as in straightrun gasolines or heavy cracked naphthas. Comparison of the data on Item 5 shows that the more expensive plant, i.e., the one containing six extraction stages, requires only a 25 per cent reagent circulation rate and 25 lb. to 30 lb. of steam per barrel of gasoline, as compared to a 50 per cent circulation rate and 40 lb. to 50 lb. of steam per barrel in the plant with only three extraction stages, when running to 0.0004 per cent residual mercaptan sulfur. This steam saving in the more expensive plant is not so great when a higher final mercaptan content is allowed.

Comparison of the data in Tables 5 and 6 shows that, in general, the steam savings realized by the use of a better treating plant, i.e., one with more extraction and stripping stages, or a better treating solution—i.e., such as Shell Solutizer solution against sodium hydroxide with or without any natural solubility promoters—are larger as the treating job becomes more difficult. The relative difficulty of the treating operation increases as the sour stock has a higher mercaptan content, or as the proportion of high-molecular-weight mercaptans increases, or as the allowable final mercaptan content is lowered. In other words, the better the plant or solution, the lower the final mercaptan content to which it is possible to treat before the stripping-steam requirement increases sharply.

Not all gasolines contain enough acids to cause them to build up to 20 per cent of the caustic solution even when using strong caustic solution, although some will cause much higher buildups. Mason, Bent, and McCullough[8] report concentrations up to 50 per cent by weight of the caustic solution. Higher concentrations of natural solubility promoters will give larger extraction coefficients, although the increased viscosity of the solution may cause difficulties in operation of the treating plant. When starting with weaker caustic solutions, the free caustic strength may decrease far enough during the acid building to cause the extraction coefficients to fall off. Naturally, the use of a pure acid such as isobutyric, which has been selected especially for its effect on the extraction coefficient, will give higher extraction coefficients than the naturally occurring organic acids in gasoline.

As stated previously, the presence of mercaptans in gasoline results in decreased tetraethyllead susceptibility. The work of Ryan[11] puts this decrease on a quantitative basis. He shows that the percentage decrease in lead susceptibility due to mercaptan sulfur becomes relatively greater at low concentrations of mercaptans. Thus, increasing the mercaptan content of a gasoline from 0.0000 to 0.005 per cent of mercaptan sulfur results in a greater percentage decrease than increasing the mercaptan-sulfur content from 0.020 to 0.025 per cent, although the amount of mercaptan added is the same in both cases. Both de-

(Continued on Page 147)

TABLE 6—EFFECT OF INCREASING THE RESIDUAL MERCAPTAN-SULFUR CONTENT ON THE TREATING REQUIREMENTS IN THE SHELL SOLUTIZER PROCESS

		Extraction temperature = 90° F.			Solutizer solution = *K*-2 or equivalent					
			Sulfur			Solutizer solution—Gasoline-volume ratio to give residual mercaptan-sulfur content (Per cent by weight)			Stripping steam* Pounds per barrel of gasoline treated to give residual mercaptan-sulfur content (Per cent by weight)		
No.	Type of gasoline—	Boiling range (°F.)	Total mercaptan (Per cent by weight)		Number of extraction stages	0.0004	0.002	~~0.005~~ 0.0005	0.0004	0.002	0.005
1	Blend†	100-400	0.097	0.027	6	0.15	0.05	0.02	15-20	5	<5
2	Cracked	230-415	0.79	0.064	6	0.85	0.32	0.20	50-65	20-25	5
3	Cracked	100-400	0.36	0.090	6	0.12	0.03	0.01	20-25	5	<5
4	Straightrun	125-350	0.141	0.051	6	0.80	0.36	0.25	50-65	20-25	10-15
5	Straightrun	100-200	0.151	0.085	3	0.50	0.20	0.10	40-50	15-20	<5
					6	0.25	0.12	0.06	25-30	10-15	<5

*Type 2 stripping[15] (indirect), 10 theoretical plates, atmospheric pressure; does not include steam required to supply sensible heat or to make up for radiation of other losses. †35 per cent by volume of straightrun; 65 per cent by volume of cracked.

(Continued from Page 142)

creases in lead susceptibility are based upon the susceptibility of the sulfur-free gasoline. The additional tetraethyl lead fluid required to reach a certain octane number for a given decrease in lead susceptibility depends upon the lead level to which it is necessary to go. The amount of TEL solution saved is greater at high lead levels than at low.

Thus the factors of stripping steam and lead saving are interrelated. Increased expenditures of stripping steam decrease the final mercaptan content and effect an increased lead saving. This point is discussed further in the section dealing with economic comparisons.

The concentration of alkyl phenols, which is an important factor in the gum stability of a gasoline, may be controlled by adequate prewashing and by maintaining a suitable concentration in the Shell Solutizer solution.[7] Another method of controlling the concentration of alkyl phenols is to add the desired amount of them to the treated gasoline after they have been recovered from the prewash.

Copper treating.

Unlike caustic washing and the Shell Solutizer process, doctor and copper treating are not affected to any great extent by the mercaptan distribution. The total mercaptan content is of much more importance.

Chemicals consumed in the copper processes are mainly oxygen and reagent. The slurry process requires pure oxygen in about 1 to 1½ times the amount called for in the sweetening reaction. The oxygen is dissolved in the gasoline before it contacts the slurry. The solubility of oxygen in the gasoline is a limiting factor in the use of this process, because undissolved oxygen increases reagent carry-over from the treating vessel. The liquid process depends upon air blowing for regeneration and, of course, has no oxygen cost. The various solid or bed processes use either air or pure oxygen, depending upon the stock and process. Carry-over of reagent and incomplete regeneration due to fouling of the reagent affect the amount of copper used.

The water is formed in the over-all sweetening reaction, i.e., $2RSH + \frac{1}{2}O_2 = RSSR + H_2O$. With high mercaptan contents, the amount of the water formed exceeds that soluble in the gasoline, and accumulates in the reagent. This water interferes with the proper operation of any but the liquid treating process, and must be removed. Drying the untreated gasoline with rock salt or by chilling, and increasing the solubility of water in gasoline by heating the gasoline, have both been used suc-

JOHN ZINK BURNERS

OVER FIFTY TYPES OF BURNERS PROTECTED BY 20 U. S. PATENTS

SPECIAL BURNERS MADE TO ORDER FOR SPECIAL APPLICATION; for example, when the refining industry does something new such as the development of petroleum chemistry the operators think of John Zink Burners—JOHN ZINK BURNERS will dry the cells in the new electrolytic process for making Magnesium out of Ocean Water.

JOHN ZINK BURNERS

YOU CAN'T BEAT JOHN ZINK BURNERS FOR ANY COMBUSTION NEED

Main Office and Plant:
4401 South Peoria, TULSA, OKLAHOMA

Branch Offices: NEW YORK CITY—DETROIT
LOS ANGELES—ATLANTA

cessfully for this purpose. Fig. 3 shows the amount of water formed when gasolines of various mercaptan contents are treated. The solubility of water in several Mid-Continent gasolines at different temperatures also is shown in Fig. 3. Copper treating is applied usually to gasolines with less than 0.05 per cent mercaptan sulfur.

Cracked gasolines have a tendency to retain small amounts of copper which seriously affect the gum stability of the gasoline. Sodium-sulfide washes and the addition of metal deactivators have minimized this difficulty; spent-caustic prewashes for hydrogen sulfide have been used for sodium-sulfide washes.

Ryan[11] has shown that equal weights of mercaptan or disulfide sulfur have the same effect on tetraethyl lead susceptibility, but that disulfide sulfur has a slightly more detrimental effect on octane number than the corresponding mercaptans. Thus copper treating, in which mercaptans are converted quantitatively to disulfides, results in a slight decrease in octane number with no change in lead susceptibility.

Doctor treating.

In estimating costs and chemical consumptions for a proposed doctor plant, most refiners use their own data and experience. The caustic and sulfur consumptions are connected directly with the mercaptan content of the stock. Although the litharge cost can vary from almost nothing in a well-operated and designed plant to almost stoichiometric proportions in a poorly operated plant, certainly the litharge cost is affected by the sourness of the stock.

Important considerations in evaluating the doctor process are the product loss in blackstrap and increased tetraethyl lead consumption due to decreased lead susceptibility. Ryan[11] shows that the addition of only 0.002 per cent by weight of sulfur as *t*-butyl tetrasulfide results in a decrease in octane number of 0.5 units. Approximately six times this amount of sulfur as *t*-butyl trisulfide is required to produce an equal effect. As stated previously, only a slight decrease in octane number results from conversion of mercaptans to the corresponding disulfides. The same effect is encountered with the lead susceptibility. Mercaptan and disulfide sulfur have the same effect. Sulfur as polysulfide sulfur has the same effect as 2.29 times this amount of sulfur as disulfide, or mercaptan sulfur, in decreasing the lead susceptibility. The importance of avoiding polysulfide formation, particularly tetrasulfide formations, during doctor treatment is clearly evident.

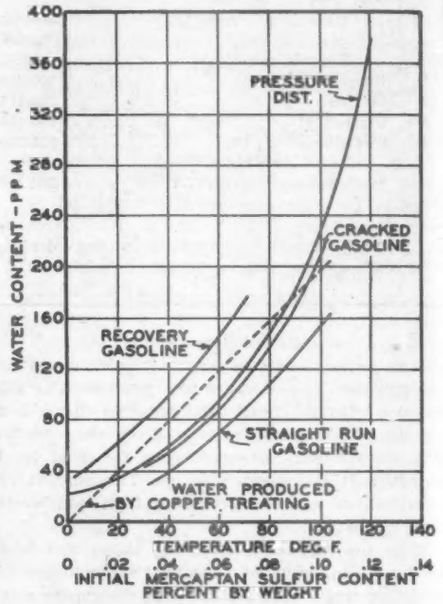


Fig. 3—Solubility of water in gasolines and amount of water produced by copper treating gasolines of various mercaptan-sulfur contents

Unisol process.

The Unisol process stands midway between caustic washing and the Shell Solutizer process, on the one hand, and doctor and copper treating, on the other. It is relatively insensitive to the mercaptan distribution and the total mercaptan content. The recommended reagent circulation rate, 2 per cent by volume of caustic and 0.8 per cent by volume of methanol, is the minimum compatible with efficient operation of the process, and is sufficient to treat gasolines containing up to 0.07 per cent of mercaptan sulfur or more. Pilot-plant and full-scale data indicate that this amount of reagent will produce a gasoline either doctor-sweet or just on the border line. Full-scale operation has produced some early difficulties which, for the most part, have been overcome.

In the design of the full-scale plants operating on the Unisol process, provision has been made for increasing the caustic circulation rate to 4 per cent. In actual operation, however, the 2 per cent figure has not been exceeded. In view of the fact that this minimum reagent circulation rate is maintained, the steam cost is fixed at that amount necessary to strip all the methanol from the reagent and to recover the methanol from the water-alcohol mixture from the mercaptan separator. Hence, the final mercaptan content is fixed at that figure to which this amount of reagent will scrub the gasoline, and no saving would be effected by increasing the allowable mercaptan content of the finished gasoline. With stocks that are more sour, requiring a higher circulation rate, some saving might be effected. However, as the process never has been tried on such stocks, no actual data are available.

Acidize the Chemical Process Way

This is no time for inefficient oil wells. Every extra barrel of oil, which can be obtained without the use of critical war materials, is needed and is imperative.

CHEMICAL PROCESS is the basic method of acidizing for "all out" aid to oil wells. It's the safe, sure way to make your wells fully productive . . . at low cost. So, be sure to specify CHEMICAL PROCESS for outstanding results!

CHEMICAL TREATMENT
THE CHEMICAL PROCESS COMPANY
OF OIL AND GAS WELLS

MAIN OFFICES; PHONE 206 BRECKENRIDGE, TEXAS

PHONE, WIRE OR WRITE YOUR NEAREST CHEMICAL PROCESS SERVICE STATION

GREAT BEND, KANSAS
Tel. 1215—R. P. Maddox

HUGOTON, KANSAS
Tel. 211—F. Considine

RUSSELL, KANSAS
Tel. 493—C. B. Vincent

WICHITA, KANSAS
Tel. 2-3478—C. V. Burkett

SHREVEPORT, LA.
Tel. 2-3665—B. H. Reynolds

TULSA, OKLAHOMA
Tel. 3-0607—M. E. Chapman

BRECKENRIDGE, TEXAS
Tel. 206 & 306—C. K. West; P. W. Pitzer; G. R. Whitney; A. J. Buchanan
Tel. 745—B. M. Kingston

HOBBS, N. M.
Tel. 444—H. L. Peterman

SEMINOLE, OKLAHOMA
Tel. 844—T. S. Lancaster

BORGER, TEXAS
Tel. 359—F. Considine

LULING, TEXAS
Tel. 390—M. W. Fredeaburg

ODESSA, TEXAS
Tel. 21—C. F. Hogan

WICHITA FALLS, TEXAS
Tel. 2-4307—W. E. (Bill) Marian

LEVELLAND, TEXAS
Tel. 264—P. W. Morrison

DENVER CITY, TEXAS
Tel. 54

HOLLIDAY, TEXAS—Tel. 64—W. S. Pate

THESE THINGS WE MUST DO

WE MUST CONSERVE VALVES NOW IN SERVICE . . . EXTEND THEIR LIFE . . . FORESTALL THE NEED FOR REPAIRS AND REPLACEMENTS

New valves represent materials which have become "precious metals." They embody man hours desperately needed in our war effort. And their shipment to point-of-use requires transportation facilities which cannot be spared except for the most vital of products.

Under such conditions, our duty is clear. We must protect and preserve valves already in use. Our program of maintenance must be re-appraised in the light of new conditions — made more exacting, more inflexible, more effective than ever before. Every man who handles valves must be trained in their proper operation and service. For reasons of both patriotism and self-interest, we must redouble our efforts to extract from every existing Jarecki Valve all of the extra service that has been built into it.

JARECKI

MANUFACTURING COMPANY

"Since 1852"

General Offices: St. Louis, Mo. Home Office and Factory: Erie, Pa. U. S. A. District Offices: Pittsburgh, Pa., Tulsa and Bartlesville, Okla., Dallas and Houston, Texas; Mt. Pleasant, Mich.; Centralia, Ill.; Owensboro, Ky.

Branch Stores at All Important Places in the Oil Country

The induction period of the treated gasoline is controlled by carrying the correct amount of alkyl phenols in the treating solution.

The only methanol loss in the process is the slight amount, 0.004 per cent by weight,[8] which is carried away in the exist gasoline. No methanol loss should be encountered in disposing of the mercaptans taken overhead with the methanol, when the water concentration is controlled.

Economic Comparisons

Consideration of the characteristics of the various treating processes, and a knowledge of the gasolines and other conditions prevailing at a particular refinery, will help the refiner to make a choice of the several processes which look favorable. A preliminary comparison based upon steam cost, tetraethyl lead cost, and royalty is often valuable in eliminating all but those processes which are worthy of full consideration in a particular instance.

Next a complete economic comparison of these processes should be made. Unit cost can be obtained from the licensors of the various processes. Tetraethyl lead credit or debit can be either calculated or measured. The discussion of each process should aid in making this comparison.

In regard to the cost picture of caustic washing and of the Shell Solutizer process, ideally the increased operating cost necessary to wash to low mercaptan contents should be balanced against the lead savings at each mercaptan level. In this way, provided the gasoline odor is satisfactory, the refiner should determine the mercaptan content to which his gasoline should be treated. Happel and Cauley[35] have shown that, from an odor and corrosion standpoint, 0.005 per cent mercaptan sulfur is permissible in most cases. Even in congested areas with many multicar garages, it should not be necessary to go below 0.002 per cent because of odor considerations.

In order to illustrate the savings which might be effected by the choice of the proper final mercaptan content, the cost of treating to various final mercaptan contents by caustic washing and the Shell Solutizer process has been calculated. The results are plotted in Fig. 4 as the per cent of the cost of complete sweetening vs. final mercaptan contents. Inasmuch as the doctor and copper processes operate satisfactorily only when a sweet product is being produced, no curve can be shown for these processes. Similarly, a curve for the Unisol process might be drawn only for a gasoline with a much higher initial mercaptan content. No data on this possibility are available at present.

The gasoline used for these comparisons was a blend of 65 per cent cracked and 35 per cent straightrun gasoline from Mid-Continent crude. Principal characteristics of the gasoline are tabulated in Table 7.

TABLE 7—CHARACTERISTICS OF MID-CONTINENT GASOLINE BLEND

65 per cent cracked—35 per cent straightrun:	
Boiling range, °F.	100-400
Mercaptan-sulfur content, per cent by weight	0.027
Total sulfur content, per cent by weight	0.097
A.S.T.M. octane No.:	
Without addition of TEL	63.5
With addition of 1 ml. TEL per gal.	69.7
With addition of 2 ml. TEL per gal.	72.6
With addition of 3 ml. TEL per gal.	74.5

Utilities, repairs and maintenance, and chemical costs were obtained from the licensors of the Shell Solutizer process. Caustic-washing requirements were estimated the same as those of the Shell Solutizer process except for the items of steam and chemicals. Stripping-steam consumption was estimated from Equation 1 and by comparison with data on the Shell Solutizer process. Tetraethyl lead savings at 72 octane number were determined at the doctor-sweet and 0.005 per cent mercaptan-sulfur levels, and calculated for intermediate points. The gross operating cost at each mercaptan level was credited with the tetraethyl lead saving based on the raw gasoline. Labor costs were assumed the same for each process. Royalty and plant-depreciation costs were not included in the calculations.

A glance at Fig. 4 will show the large savings possible when a mercaptan-sulfur content between 0.001 and 0.004 per cent is specified instead of the doctor test. Naturally, the minimum point on these curves will fall at different points for different gasolines, but the same general effect should be noted in all cases. In general, the size of the plant required and the stripping-steam consumption are out of proportion to the additional tetraethyl lead saving realized when the doctor-sweet specification is used in connection with one of these processes.

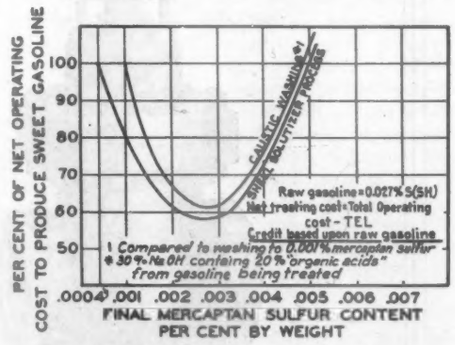

PER CENT OF NET OPERATING COST TO PRODUCE SWEET GASOLINE
100
90
80
70
60
50
CAUSTIC WASHING
SHELL SOLUTIZER PROCESS
Raw gasoline = 0.027% S (SH)
Net treating cost = Total Operating cost − TEL
Credit based upon raw gasoline
1 Compared to washing to 0.001% mercaptan sulfur
+ 30% NaOH containg 20% "organic acids" from gasoline being treated
.0004 .001 .002 .003 .004 .005 .006 .007
FINAL MERCAPTAN SULFUR CONTENT PER CENT BY WEIGHT

Fig. 4—Plot showing the effect of final mercaptan content on net treating cost

When one considers that the doctor specification is too severe with respect to gasoline odor, that small amounts of mercaptan do not affect

YOURS FOR LOW-COST PRODUCTION

Union-Formed Wire Rope

Because **Union-Formed** (pre-formed) Wire Rope is free from internal stress, it is much slower to fatigue under the combined stresses of constant bending. In service over small sheaves or wherever bending is severe, **Union-Formed** will far outlast ordinary rope and effect a real money saving. Write or wire.

UNION WIRE ROPE CORPORATION
2102 Manchester Ave. Kansas City, Mo.
Tulsa • Houston • Chicago • Salt Lake City
New Orleans • Monahans • Portland • Ashland, Ky.

UNION Wire Ropes
The ULTIMATE LOW COST WIRE ROPE"

WRITE FOR ROPE DOPE
This periodical bulletin of wire rope facts will be sent you without charge.

5-42

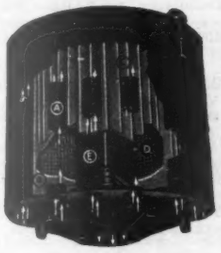
STAYNEW FILTERS

What Does the Name "STAYNEW" Mean? » » » » » » »

1. Less Wear on Engines and Compressors
2. More Service from Air-Powered Tools
3. Longer Lasting Filters

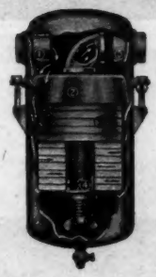
ENGINE AND EQUIPMENT SAVING FILTERS FOR THE OIL INDUSTRY

FOR ENGINE & COMPRESSOR PROTECTION



Models D, DS: Permit only clean, dust-free air to be drawn into engine and compressor intake. Feltex Filtering Medium (B) in Radial Fin Construction (C) provides greatest possible filtering area and efficiency with continued low restriction to air flow. (A) Silencing Chamber (Model DS only); (D) Galvanized Mesh Frame; (E) Reinforcing tube. D and DS Protectomotors make new engines and compressors stay new—add to life and efficiency of old ones.

NEW "SUPER" FILTER



Models AAPH, AAPHS: A newly designed Staynew filter that removes the slightest traces of oil from air transmission lines. Widely used as a final stage in the protection of delicate control instruments. (1) Inlet; (2) Baffle; (3) Solid Feltex discs through which all air must pass; (4) Perforated Liner; (5) Outlet; (6) Shell; (7) Drain Cock; (8) Swing Bolts (Model AAPHS only) for easy inspection.

FOR COMPRESSED AIR & GAS LINES

Models CP, CPH: Thousands in use throughout the oil industry. Guaranteed delivery of clean, dry air, free from dust, dirt, pipe-scale, rust, water — air-powered tools operate more efficiently, last longer. Like all Staynew and Protectomotor filters—easy to inspect, easy to clean, low restriction to air flow, long lasting. Models for horizontal and vertical installation. (1) Container; (2) Baffle; (3) Insert Housing; (4) Filter Insert in Radial Fin Construction; (5) Drain Cock.

Representatives in Principal Cities

Get the Entire Story!

Find out about Staynew and Protectomotor engine and equipment-saving features: Radial Fin Construction—Feltex and Glastex Filtering Mediums—*Double* Counter-clockwise Rotating Curtains—Fire-resistant Wire Kladding, etc.

Catalog describes entire line, including filters for building ventilation.

WRITE FOR COMPLETE CATALOG

PROTECTOMOTOR 99 10 Per Cent AIR FILTERS

STAYNEW FILTER CORP.

5 Centre Park, Rochester, N. Y. *"Filter Headquarters"*

the stability of the gasoline if the alkyl-phenol content is controlled, and that meeting this specification increases the treating cost considerably, the usefulness of the doctor test as a gasoline specification is seriously questioned. In view of the present national emergency, the continued expenditure of large amounts of vital chemicals such as litharge, caustic, and tetraethyl lead to meet an arbitrary test does not seem to be justified.

Once the economic comparison has been developed, the final choice of a treating process can be made. In making this choice, the flexibility of the process to fit in with future developments naturally should be taken into account.

A review of technological advances in refinery processing, showing how these advances have been followed by variations in treating methods, is given as an indication of what may be expected:

1. When only straightrun gasoline was produced, treatment was almost entirely by the doctor process.

2. With the invention of cracking, it was necessary to use sulfuric acid or clay treating, prior to doctor treatment, to obtain the desired gum and color stability.

3. By the use of gum inhibitors, the need for acid or clay treatment was reduced considerably.

4. Discovery of tetraethyl lead and studies of the effects of sulfur compounds upon tetraethyl lead susceptibility,[31] along with a better understanding of the factors which influence gasoline quality, have depreciated the doctor process, and have stimulated searches for other processes.

5. Increases in octane levels of motor fuels were accompanied by development of the copper chloride-treating and mercaptan-removal processes.

6. Catalytic processes also have been extended to gasoline-treating operations.

Some examples of recent changes or trends which also may influence treating operations are:

1. Increase in total sulfur specification of gasolines from 0.10 to 0.25 per cent. This will allow wider use of high-sulfur oils, or will decrease the treatment required.

2. More widespread use of catalytic, alkylation, and polymerization processes. This will tend to increase the proportion of cracked gasolines which may be treated satisfactorily by mercaptan-removal processes because of their more favorable mercaptan-sulfur distributions.

3. Changes in crudes processed. These are not always predictable or anticipated but, if known, should not be underrated in their effect upon treating problems. Indications are that higher-sulfur crudes will come more into the picture in the future.

References

1. V. A. Kalichevsky and B. A. Stagner, Chemical Refining of Petroleum, revised edn., Reinhold Publishing Corp., New York (1942).
2. H. W. Field, "The Caustic-Methanol Mercaptan Extraction Process," The Oil and Gas Journal, 40 (20) 40 (1941).
3. C. F. Mason, R. D. Bent, and J. H. McCullough, "Naphtha Treating 'Pays Its Way,'" Proc. A.P.I. 22 (111) 45 (1941).
4. U. S. Patent 2016271 (1935).
5. R. G. Atkinson, "Slurry-Type Copper Treater Stops Octane Number Losses," Natl. Petroleum News 32 (50) R-450 (1940).
6. "Catalytic Treating Cuts TEL Expenses," Natl. Petroleum News 32 (50) R-454 (1940).
7. D. L. Yabroff, E. L. Walters, A. C. Nixon, and H. B. Minor, "Solutizer Sweetening Preserves Inhibitor Susceptibility," Natl. Petroleum News 32 (50) R-445 (1940).
8. D. L. Yabroff and A. C. Nixon, "The Improvement in Octane Number and Lead Susceptibility Resulting From Solutizer Sweetening," Refiner Natural Gasoline Mfr. 19 (3) 73 (1940).
9. C. D. Lowry, Jr., "The Plumbite Sweetening of Gasoline," U.O.P. Booklet No. 242, May (1940).
10. C. Wirth, III, and G. B. Murphy, "A Study of Some Gasoline Sweetening Reagents," The Oil and Gas Journal 34 (38) 28 (1936).
11. J. G. Ryan, "Influence of Sulfur Compounds on Octane Number and Lead Susceptibility of Gasolines," Ind. Eng. Chem. 37, 824 (1942).
12. L. M. Henderson, W. B. Ross and C. M. Ridgway, "The TEL Susceptibilities of Gasoline Treated With 'Doctor' Solution Vs. Caustic Washing," Ind. Eng. Chem. 31, 27 (1939).
13. M. W. Conn, "Perco Copper Sweetening," Refiner Natural Gasoline Mfr. 20 (3) 53 (1941).
14. D. L. Yabroff and L. E. Border, "The Solutizer Process for the Extraction of Mercaptan," Proc. A.P.I. 20M (3) 95 (1939).
15. D. L. Yabroff, E. R. White, and A. V. Caselli, "The Regeneration Step in the Solutizer Process for the Extraction of Mercaptans," Proc. A.P.I. 20 (3) 57 (1939).
16. D. L. Yabroff and E. R. White, "Action of Solutizers in Mercaptan Extraction," Ind. Eng. Chem. 32, 950 (1940).
17. A. M. Martin and L. Carlson, "Catalytic Desulfurization by Use of the Gray Process," The Oil and Gas Journal 40 (46) 138 (1942).
18. F. G. Graves, "Factors in Knock Rating and Lead Susceptibility of Gasolines," Ind. Eng. Chem. 31, 850 (1939).
19. "Mercaptans Removed Prior to Doctor Treating," Refiner Natural Gasoline Mfr. 21 (4) 59 (1942).
20. C. Wirth, III, C. D. Lowry, Jr., and J. R. Strong, "Studies in Doctor Sweetening: 2—Regeneration of Spent Doctor Solution," paper presented before Petroleum Division, Am. Chem. Soc., Milwaukee, Wis., Sept. 7 and 8 (1938).
21. "The Use of U. O. P. Inhibitors," U. O. P. Booklet No. 224, May (1938); Revised Apr. (1940).
22. H. S. Norman, "Sun Oil Operating Large Houdry Catalytic Gasoline Treating Unit at Marcus Hook," The Oil and Gas Journal 33 (46) 106 (1940).
23. D. L. Yabroff, "Extraction of Mercaptans With Alkaline Solutions," Ind. Eng. Chem. 32, 257 (1940).
24. J. Happel and D. W. Robertson, "Removal of Mercaptans From Naphtha by Caustic," Ind. Eng. Chem. 27, 941 (1935).
25. J. Happel and S. P. Cauley, "Significance of the Doctor Test for Gasoline," Proc. A.P.I. 21M (3) 96 (1940).
26. L. M. Henderson, M. S. Agruss, and G. W. Ayers, Jr., "Effect of Sulfur and Sulfur Compounds in Naphtha Upon Certain Corrosion Tests," Ind. Eng. Chem. (Anal. Edn.) 12, 1 (1940).
27. L. M. Henderson, G. W. Ayers, Jr., and C. M. Ridgway, "Caustic Washing of Gasoline and Caustic Regeneration," The Oil and Gas Journal, 38 (46) 114 (1940).
28. A. Kremser, "Analysis of Oil Absorption Problems," The Oil and Gas Journal, 29 (1) 146 (1930).
29. W. E. Green, "Flue Gas Abolishes Refinery Smells," Natl. Petroleum News 19 (20) 92 (1927).
30. Birch and Norris, "The Chemistry of Petroleum," J. Chem. Soc. (Lon.) 127, 898 (1925).
31. Brooks and Parker, "The Volatile Yellow Coloring Matter in Cracked Gasoline," Ind. Eng. Chem. 16, 6 and 587 (1924).
32. D. B. Luten, F. A. Bent, and M. L. Griffin, "Petroleum Cresylic Acids," Soap 16 (1) 97 (1940).

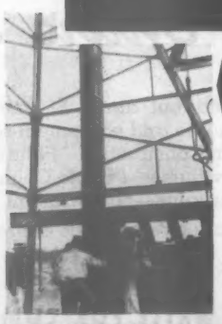
VITAL IN WAR . . .
ESSENTIAL IN PEACE

NO OTHER LIGHT-WEIGHT PIPE CAN MATCH NAYLOR PERFORMANCE

IT *saves weight*
IT *saves steel*
IT *speeds installation*
IT *saves handling costs*
IT'S *leak-tight*
IT'S *safer*
IT *saves maintenance*
IT *saves money*

Naylor's steel-saving, money-saving line pipe is an old reliable in gas-gathering service—ideal for vacuum lines or lines eventually to be operated under vacuum. Sizes—4" to 30" in diameter, 14 to 8 gauge. All types of fittings, connections and fabrication.

Call our distributor or write for Catalog



NAYLOR THREADED SURFACE CASING

is equally outstanding in service. No joint welding or field welding equipment required. The Spiral helps centralize Naylor Casing in the hole—helps prevent channeling—insures a better cementing job. Uniform lengths, light weight and accurate threading speed handling and setting — save money. Sizes 13⅜" O.D. to 20" O.D. Interchangeable with A.P.I. standard casing.

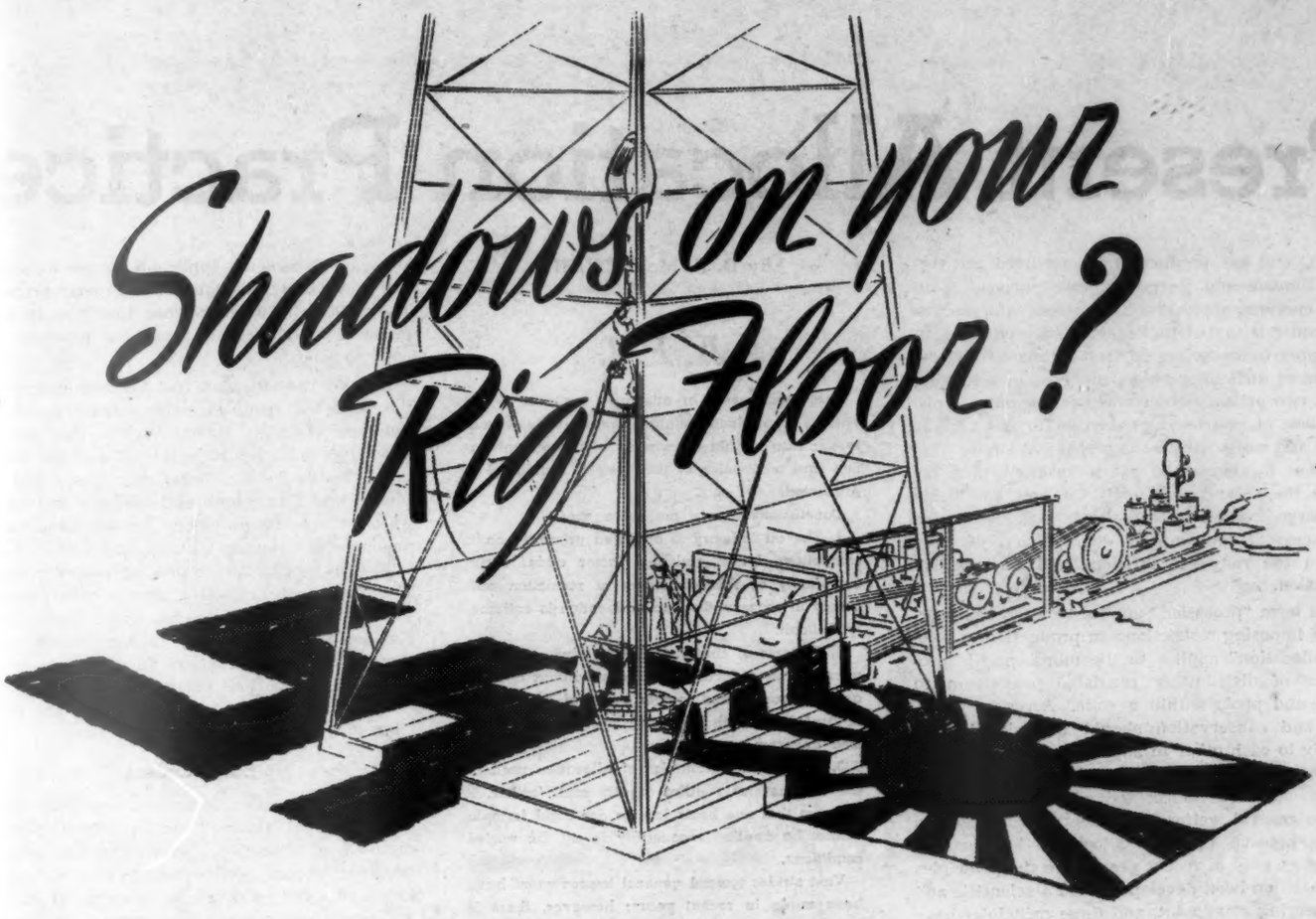
YOUR DEPENDABLE SOURCE OF SUPPLY
FOR LINE PIPE AND SURFACE CASING

NAYLOR PIPE COMPANY
1232 East 92nd Street, Chicago, Ill.

MID-CONTINENT SUPPLY COMPANY
Fort Worth, Texas and Branches

Exclusive Distributors in Arkansas, Kansas, Louisiana, New Mexico, Oklahoma and Texas.

Shadows on your Rig Floor?



Yes, these shadows are on your rig floor if you are running without proper lubrication, true alignment, systematic care and inspection.

Fortunately, there are ways to erase these shadows; to cover your rig, instead, with the stars and stripes of Old Glory. Here are a few ways to do it: 1. Keep shafting straight and bearings in line. 2. Grease all bearings and bushings each tour. Sheaves, too! 3. Use a relief valve on power pump, with the recommended size safety pin. 4. Pit should never be more than 6' below pump; suction line without elbows and never more than 30' long. 5. Keep brakes properly adjusted, with no cut off valve on water line to brake flanges. 6. Run table at (or below) speeds recommended by manufacturer.

Once again, may we suggest that the FREE Wheland Lubrication Chart will be a big help to all crews and executives? Written by experts, this chart is a sharp tool for cutting costs, increasing the life and service of your rig. We offer it as a wartime service. Absolutely no obligation.

DISTRIBUTORS:

Lucey Products Corporation, Tulsa, Okla.; Houston Oil Field Material Co., Inc., Houston, Texas; Murray-Brooks Hardware Co., Ltd., Lake Charles, La.; Frick-Reid Supply Corporation, Tulsa, Okla.

EXPORT:

Lucey Export Corporation, 3505 Woolworth Bldg., New York, N. Y.; Broad Street House, London, E.C. 2, England.

THE WHELAND COMPANY

ROTARY DRILLING EQUIPMENT

Chattanooga, Tenn.

Present Allocation Practices

By D. R. McKEITHAN
Phillips Petroleum Co., Bartlesville, Okla.

A. P. I.

The development of allocation methods in the various oil-producing states is reviewed and analyzed; also a brief description of the administration and mechanics of the systems employed is presented.

Conclusions drawn therefrom are:

1. The oil industry is operated primarily on a competitive basis, and this factor adds to the complexity of the attainment of maximum efficiency in conservation, and allocation is extremely difficult.

2. Systems of control in the various states are geared to meet local operating conditions as well as background and temperament of the people in conformity with American standards of localized government.

3. The actual mechanics of allocation used in the various states differ greatly and, further, it appears that one basic law or one rigid formula cannot be applied reasonably to all the varied conditions.

Vast strides toward general improvement have been made in recent years; however, there is still room for considerable betterment; and the "Standards of Allocation of Oil Production Within Pools and Among Pools," as set out in the report of the American Petroleum Institute's Special Study Committee on Well Spacing and Allocation of Production, should be of material assistance in further progress.

Paper presented before Division of Production at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

OIL and gas production is restricted for two fundamental purposes. One purpose is to limit current supply to consumptive requirements. The other is to distribute regulated production in a manner to insure the greatest ultimate recovery. The most difficult problem involved in achieving these two primary objectives is the equitable distribution of restricted production to the various pools and wells within the respective states. This problem is aggravated at the present time because the reserves of many oil and gas fields are large enough to withstand production rates in excess of consumptive demand and yet stay within the range of efficient and conservative operation.

The term "proration" applies to the broad process of imposing restrictions on production, whereas "allocation" applies to the more specific procedure of distributing regulated production to wells and pools within a state. Actually, proration and conservation should be related very closely to each other in any successful system.

The need for proration has been demonstrated amply, and now is accepted widely as necessary to the general welfare. To meet this necessity a comprehensive plan of allocation is essential. However, only in recent years have the principles of allocation been developed from a scientific and engineering standpoint, and these principles have yet to be embodied firmly in the regulatory process. For this reason, proper allocation of production is the most important and commanding phase of the current proration problem.

The economic aspects of proration are related too closely to the general problem to be overlooked entirely in any successful allocation system. The discovery and production of oil and gas is not only a highly competitive business, but one of uncertain financial gain. Therefore, any restriction of production strikes directly at the very economics of operation. For this reason too, additional importance is placed on proper allocation in the over-all problem of proration.

In discussing allocation practices used in the various states, it is interesting to observe how the problem has been approached and to what extent it has been solved. Naturally, most systems differ from one another due to the background of their evolution as well as to local physical and political conditions. For an easier understanding of methods currently used, it might be helpful to review briefly the general historical background of proration and allocation.

Historical Background

In the early days of the industry, oil and gas became the property of the one reducing it to possession. The "capture" principle became the prime factor in establishing development and production practices. It led to reckless drilling of newly discovered reservoirs, to the drilling of excessive numbers of wells, and to the unsound elevation of well potentials as the index of successful operation. These practices were grossly unsound in the light of present engineering knowledge. In fact, the solution of some of the problems of allocation has been attained by a true understanding of the errors in these early conceptions.

In those early days the open-flow methods of producing resulted in great instability of the industry. Periods of feast and famine followed each other, depending upon the rate of discovery, the life of flush pools, and the aboveground supply of crude oil. Producers were always at the mercy of the purchasers operating under the law of "supply and demand." Purchasers even prorated, but such proration was seldom on a ratable or equitable basis. Prices were reduced drastically, and selective buying between pools and within pools flourished. The states of Oklahoma, Texas, Louisiana, New Mexico, and Michigan passed common purchaser laws which, to some degree, corrected the situation. In a broad sense, these were the first laws dealing with proration. Many trying years elapsed before any further corrective measures were attempted.

Curtailment Inevitable

During the period 1926 to 1931 such prolific pools as Yates, Hobbs, Hendricks, Oklahoma City, Kettleman Hills, and East Texas so disrupted the already unbalanced economic situation that some type of curtailment became inevitable. Few precedents existed on which the regulations sought could be patterned. The industry was plunged into a more or less trial-and-error method of achieving efficient regulatory control. In 1915 the Oklahoma Legislature had passed a primitive conservation law, but for 12 years thereafter this statute was used only for purposes of giving the Corporation Commission some voice in approving voluntary proration agreements. Early proration in the Seminole field was of this type. Similar voluntary proration plans were worked out later by operators at Yates, Hobbs, Hendricks, and Kettleman Hills. Some of these methods of proration were quite satisfactory, but they were only stop-gap agreements applicable to the local problem and wholly inadequate for general proration. They did provide experience that was to be of material assistance in proration practices that were to follow.

In 1930 the situation had become critical, and the industry required some means of reaching economic stability. It was obvious that the various states must control crude-oil and gas production through forceful legal regulations and that some control over both underground and surface waste had to be provided. At the same time a principle of "ratable taking" also had to be established for the protection of property rights. The first truly effective conservation statutes were enacted in Louisiana, 1930; Texas, 1931; Kansas, 1931; Oklahoma, 1933 (revised). Since that time these four states further have revised and modernized their conservation laws. In addition New Mexico, Arkansas, Michigan, and Mississippi have joined with effective laws.

Early Orders

The first proration orders were based primarily on individual flat-well or open-flow potential methods of allocation. No weight was given to acreage; proper well spacing was almost unheard of; and evidence on reservoir conditions and performance was unsatisfactory. Widespread differences of opinion prevailed between operators, engineers, and geologists on the basic theory as well as on the actual mechanics involved in the practice of proration. Many upsets and discouragements were encountered in the search for a sound and foolproof program. The courts were crowded, and much waste was committed in the name of conservation.

The progress that has been made is marked by a better understanding of the technical phases of reservoir performance, and by a full appreciation of the degree of conservation achieved under restricted rates of flow.*

From the beginning the courts almost invariably have upheld the legal principles involved and the authority of the states to follow reasonable practices in the application of regulatory statutes. When Champlin carried its fight on proration in the Oklahoma City field to the Supreme Court of the United States, it was established that proration based upon potential was not confiscatory and did not violate the federal constitution. In another case the same court held that a state (Texas) has the power to limit and prorate gas production either in the public interest or to protect correlative rights (Thompson vs. Consolidated). Another court upheld California's right to limit the gas-oil ratio, either to prevent waste of common reservoir energy or to "adjust coexisting rights." (Bandeni vs. Superior Court). The Supreme Court of Oklahoma (Patterson vs. Stanolind) sustained the power of the state to prescribe drilling units and to compel unitization of small tracts. The Supreme Court of Texas recently upheld the Railroad Commission of Texas in its policy of first ascertaining the market demand for the entire state and then allocating the same to the various pools on a reasonable state-wide formula (Continental vs. Railroad Commission of Texas). These and many

*Attention is called to an outstanding early-day engineering study: The Function of Natural Gas in the Production of Oil, by H. C. Miller. Also other important works on the subject are listed in the engineering bibliography section of Standards of Allocation of Oil Production (referred to later in this paper).

Houdry Process Corporation
and
Bechtel-McCone-Parsons Corporation

Announce the appointment of Bechtel-McCone-Parsons Corporation as engineers, constructors and licensing agents for all Houdry processes, including:

Houdry Catalytic Cracking

Thermofor Catalytic Cracking

In addition to a complete service on Houdry processes, we continue to offer well-rounded engineering and construction services covering all types of refining and chemical plants.

Bechtel-McCone-Parsons Corporation

*Engineers – Constructors**

---

*SPECIALIZING *in petroleum refineries and chemical process plants. Staffed to perform any or all of the following services, wherever men and materials can be delivered:* ENGINEERING • DESIGN • PROCUREMENT • CONSTRUCTION • BUSINESS ANALYSIS • MANAGEMENT OF OPERATION. *Offices: 601 West Fifth Street, Los Angeles, Calif. — 220 Montgomery Street, San Francisco, Calif.*

bmp

BUT FOR WIRE ROPE—
A FIST-GRIP CLIP
THAT CANNOT
FINGER-PINCH
Four flat bearing surfaces give the Laughlin Safety Clip a four-square Fist-Grip on wire rope. No finger-pinching U-Bolt to bite and bend the strands, weakening them under high tension and whipping.
95% of Rope Strength delivered with the Fist-Grip Safety Clip is proved by competitive tests, three Safety Clips holding when the rope snaps under four U-Bolt Clips. Fewer clips mean savings in time and money. And inexperienced help can't put them on backwards — the saddles are identical.
25% STEEL SAVED FOR WAR NEEDS —
For an assembly of equal strength, Safety Clips use 25% less steel than a U-Bolt assembly. You are saving precious steel available for ships, tanks and guns when you use Safety Clips. Remember — they don't crimp and crush wire rope — no expensive waste from cut-off rope ends.
These Safety Savings Can Be Yours
No rope crimping — rope saved
Can't go on backward — accidents saved
Bolts on opposite sides — tightening time saved
No battered, bent threads — clips saved
No special wrench — tools saved
Fewer clips needed — clips saved
Fewer rope breaks — accidents saved
Sold Through Oil Field Supply Stores
Look for Laughlin Products in Composite Catalog
THE THOMAS LAUGHLIN COMPANY
PORTLAND, MAINE

other decisions form the framework of the present legal status of proration.*

The problem of producing from each reservoir the greatest ultimate volume of oil in the most equitable and economical manner stands before the industry today as the real problem of conservation and allocation. Probably the most complete and authoritative guide on the subject is Standards of Allocation of Oil Production, a report published in 1942 by the members of the American Petroleum Institute's special study committee on Well Spacing and Allocation of Production. It is suggested that this excellent work be followed closely while reviewing and analyzing the current proration activities of the various states.

The success attained in meeting the allocation problem squarely depends, to a great extent, upon the mechanics of the system employed and the administration thereof by the regulatory authorities. Such systems, as adopted by the states, certainly must provide for the proper distribution of production, in addition to regulations governing the efficient use of reservoir energy. Although state authorities have been conscientious in their application of the most improved methods, they have failed in many cases to meet present-day needs completely. It is regretted that the experience and advice of the outstanding leaders of the industry have not always been used more effectively.

The war emergency is causing many abrupt changes in state procedure. In order effectively to synchronize the oil industry to the national war effort, the federal Government has imposed certain administrative controls through the Office of the Petroleum Coordinator for War. In effect, this means that the industry is under a form of federal-state dual control.

The requirements of crude from the various states now are designated each month by the petroleum coordinator. The need for particular types of crude oil, at certain points in definite quantities without delay, obviously makes this action necessary. The petroleum coordinator, consequently, greatly influences the allocation picture in each state.

Due to shortage of steel and other critical materials, certain restrictions on drilling and well spacing also are imposed by the federal Government through the War Production Board's Conservation Order M-68. Under this order wells generally must be drilled on units of not less than 40 acres in size—even in old pools partly developed on a closer spacing plan. The situation caused by limitations on drilling naturally has created new problems for state authorities in regard to equitable allocation of production within pools.

In the following discussion on allocation practices used in the various states, only a brief outline of the administrative organization, along with an over-all description of the mechanics of allocation of oil production, will be attempted.

Arkansas

Proration and conservation in Arkansas are enforced by the Oil and Gas Commission, consisting of seven members, appointed by the governor for staggered terms. The commission is composed of men experienced in the production of oil in Arkansas, and they serve without salary. A full-time director of conservation is employed to administer its rules, regulations, and orders.

The conservation statute specifies that the va-

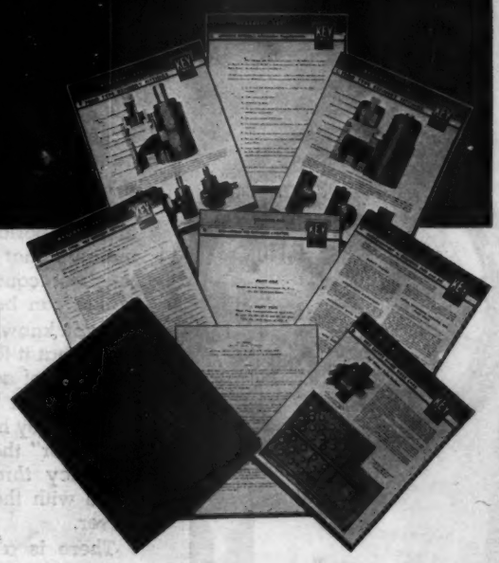
*For more complete legal history, reference should be made to "Phases of Legal History and Practical Operation of Conservation of Oil by the States in Relation to Ascertainment of Limits of Desirable Program of Assistance by the Federal Government," a paper presented by R. E. Hardwicke to the subcommittee (Cole committee) of the Committee on Interstate and Foreign Commerce, House of Representatives, 76th Congress, 3rd Session, on H.R. 290 and H.R. 7372, p. 1465 (1940). For additional legal reference, see legal bibliography section of Standards of Allocation of Oil Production.

USE KEY STANDARDS To Cut Detail Work

A SECTION OF THE KEY ENGINEERING DEPT.

SPECIFY KEY RETURN BENDS and SPECIAL REFINERY FITTINGS

Standardization requires definite standards from which to work . . . in building new refineries—or in converting present ones to high-octane recovery or producing rubber constituents.

Key was ready with the answer to this immediate war problem. First: Because we have pioneered the development of these standards over a period of years; Second: Because our specialization in producing Refinery Fittings and Return Bends made it logical for us to establish the standards with the cooperation of the refinery engineers.

Whether it is a matter of new building or of plant conversion—you can speed up at every point—from the layout detailing to actual production by working with Key Proven Standards.

If your engineering department is not fully supplied with complete sets of Key Standard Bulletins, write today for additional copies.

KEY Refinery Fittings for . . .
CATALYTIC CRACKING . . . HYDROGENATION . . . POLYMERIZATION . . . ISOMERIZATION . . . REFORMING . . . ALKYLATION . . . STYRENE . . . BUTADIENE . . . TOLUENE

KEY COMPANY
EAST ST. LOUIS, ILL.
CHICAGO · NEW YORK · PITTSBURGH · TULSA · HOUSTON · LOS ANGELES

rious pool allowables be established at the most efficient rate of flow. There is no mention in the law that market demand in any form is to be recognized in the establishment of any allowables; however, reductions in pool allowables have been made in the absence of any justification other than a reduced market demand. With this system in effect, no mathematical relationship between pools is possible. Each pool, therefore, stands by itself, and in the most part the allowable is based on reservoir performance. Adequate reservoir data must be available before pool allowables are established. This technical evidence is furnished by both commission experts and engineers representing the operators. Allowables are established after open hearing, for proration periods of from 1 to 3 months.

Under this system the petroleum coordinator's monthly recommendations are not necessarily followed. However, to date no serious conflict between the two agencies has arisen as to the total state output.

In practically all fields controlled by the Arkansas Oil and Gas Commission, the total pool allowable is distributed among the various wells on a basis of acreage times bottom-hole pressure. By the use of this type of formula, drainage between properties is held to a minimum, while reservoir energy is utilized to the best advantage. Gas-oil-ratio limits are established for each pool, and in this way severe penalties are applied to oil wells producing excess volumes of gas.

Inasmuch as unnecessary drilling is prohibited by the conservation statute, operators and the commission have cooperated in establishing 40-acre spacing in practically all prorated pools. Wells must be located in the center of such 40-acre units. Unitization of small and irregular-shaped tracts to form a full drilling unit is ordered by the commission when necessary to preserve the established spacing pattern. Exceptions to the uniform pattern are granted only after special hearing, and then only for good geological reasons. Well-spacing restrictions imposed by federal Conservation Order M-68 have not interfered noticeably with the development of controlled reservoirs. The Arkansas statute prohibits state control of any nature in pools discovered prior to January 1, 1937.

The Arkansas commission has been zealous in the accumulation of scientific data on oil reservoirs under its jurisdiction, and has encouraged greatly the proper development and operation of oil and gas reservoirs. Pressure-maintenance operations also are looked upon with great favor. Although relatively new, the general effectiveness of the Arkansas system is recognized.

California

With considerable success, California operated under a voluntary plan of proration prior to 1942. Due to the lack of proper legislation the state took no active part in the regulation of production. Now, because of the war emergency, the burden of proration rests principally in the hands of the federal Government, and the operator must adhere to definite federal conservation requirements while meeting heavy war demands for crude oil. The situation is difficult, but the problems are being solved by trial and error and a great deal of all-around cooperation.

The petroleum coordinator's office not only establishes the total production quota for the state, but it prescribes also the standards by which the total is distributed to the various pools. In his Recommendation 19, the petroleum coordinator outlined the purpose and objectives of his office, with directions to the production committee of District 5 to do all things necessary: (*a*) To assure proper development, production, and utilization of reserves of petroleum and natural gas; (*b*) to make petroleum and petroleum products available at proper places to meet military and civilian needs; (*c*) to accomplish the most effective use of critical materials; (*d*) to assure the efficient use of transportation, storage, and refining facilities; (*e*) to eliminate the drilling of unnecessary wells; (*f*) to prevent physical waste above and underground; and (*g*) to assure that natural gas produced in conjunction with petroleum is used primarily for the efficient recovery of petroleum. These standards must be met fully each month before the Office of Petroleum Coordinator gives final approval of proration schedules.

The actual regulation of production, however, is administered by the Conservation Committee of California Oil Producers, which is an active subcommittee for the production committee of District 5. This committee consists of 9 members representing different producing districts, and 5 members selected at large. The primary function of the committee is that of making allocations to the various pools in conformity with the prescribed standards.

The first step used in the breakdown of total allowable is the segregation of all pools into uniform classifications. These classifications are made in such a manner as to reflect the relative producing ability of the various reservoirs:

Class 1: (Ultimate possible recovery reduced by producing at full capacity.) Flush: (*a*) Relatively undepleted flowing pools. (*b*) Relatively undepleted pools which pump a substantial portion of their production. Semiflush: (*c*) Pools generally in the intermediate stages of depletion, now using artificial lift or requiring it in the near future.

Class 2: (No loss in ultimate possible recovery by producing at full capacity.) Settled (*a*) Pools generally beyond 50 per cent depleted, but having production abilities far above the economic limit. (*b*) Pools generally beyond 50 per cent depleted,

MARSH
EMBODYING all the refinements of design and construction, learned in 75 years of gauge making, Marsh Gauges give you the highest possible degree of accuracy . . . and, even more important, the stamina to maintain that accuracy under the toughest conditions to which a gauge can be subjected.
If you know Marsh Gauges you know that it takes more to knock them out of adjustment than any other make. But unlike other gauges they have the Marsh "Recalibrator" that restores original accuracy throughout the entire scale with the twist of a screwdriver.
There is a Marsh Gauge for practically every service encountered in the oil industry.
FULL STEAM AHEAD
JAS. P. MARSH CORPORATION
2065 Southport Ave., Chicago, Ill.
GAUGES

THE EMSCO AUXILIARY STEAM ENGINE DRIVE

The EMSCO Auxiliary Engine Drive is a specially designed transmission for use with a standby drilling engine.

It can, through various clutch arrangements be used to transmit power from the standby engines to the rotary table at the same time allowing the main engine to raise the drill string.

In case of breakdown of the main engine, the power can be immediately switched to operate the drawworks, thus enabling driller to come out of the hole while necessary repairs are being made.

In the event repairs must be made on either the transmission or standby engine they can be bypassed and the rotary table driven directly from the idler sprocket of the drawworks.

The EMSCO Auxiliary Engine transmission makes for faster and more efficient drilling by eliminating complete shutdowns and reducing the wear on all equipment resulting from overloading.

Your Continental Representative will gladly furnish complete information.

★

THE CONTINENTAL SUPPLY COMPANY
General Offices: DALLAS, TEXAS
Foreign Sales Subsidiary
CONTINENTAL EMSCO COMPANY, Inc.
30 Rockefeller Plaza New York City, N. Y.
Representatives:
LONDON MARACAIBO BUENOS AIRES TRINIDAD

CONTINENTAL

SERVING THE OIL AND GAS INDUSTRIES

30th ANNIVERSARY
1942
CONTINENTAL SUPPLY CO.

An EMSCO Auxiliary Engine Transmission in operation with a Gardner-Denver Vertical Twin Cylinder Steam Engine

★

Buy U. S.
WAR BONDS
AND STAMPS

yet having productive abilities only moderately in excess of economic limit. Stripper: (*c*) Pools in extreme stages of depletion.

Pools in Class 2 are largely exempt from restriction; also a few Class 1 pools, producing high fuel-oil-yielding crudes, likewise are exempt.

In restricted pools a primary production quota is set up after a factor called "the maximum efficient rate of production" has been considered fully. This factor is determined for all Class 1 pools by an engineering subcommittee of the production committee of District 5. Production statistics and reservoir-performance data on all critical pools are assembled and studied by these engineers in the determination of such maximum rates. Values determined in this manner naturally are subject to wide variances, but the small engineering subcommittee (four to six members) thus far has arrived at maximums which, if exceeded, in their opinion would jeopardize ultimate recovery. When necessary, downward adjustments are made in pool quotas to take care of individual local conditions. A general fuel-oil adjustment then is made on all pools so as to increase the basic allowable to pools producing crudes which yield more than 34 per cent fuel oil, and reduce the allowable to pools of low fuel-oil value.

Intrapool allocation procedure varies widely over the state, with the production committee's office designating the method to be used in each individual case. There are three general methods employed and outlined as follows:

(*a*) Distribution based primarily on well potential, with gas-oil ratios and other significant production characteristics being considered also.

(*b*) In some pools the operator may nominate individual-well production rates which he feels will result in better production practice for his part of the reservoir. If these nominations do not result in offset inequities, and if the committee approves the distribution, then such nominated values form the intrapool allocation.

(*c*) For most critical pools special formulas have been adopted. These formulas differ widely in exact form, but are based on the principle of giving each well an allotment proportional to the area which it drains. To accomplish this, various factors are used either singly or in combination with each other. These factors, in addition to surface acreage, include: subsurface pressure, thickness of pay, productivity index, and even structural position.

The California system is most unusual, and certainly remarkable for its apparent general effectiveness in the face of immense war demands for crude and the many confusing elements involved in its program of conservation and allocation of production.

Kansas

Conservation in Kansas is enforced by the Corporation Commission of Kansas, which consists of three members appointed by the governor for staggered terms. A director of conservation is employed to carry out all rules, regulations, and orders of the commission.

The present system of allocation in Kansas is the result of some 11 years' evolution and, although few thoroughly understand how it operates, its impartiality is undenied. The market demand is determined for the state as a whole, each month after an open hearing. The nominations of purchasers, the recommendation of the petroleum coordinator, and the physical condition of the reservoirs are checked carefully before the state allowable is fixed.

The allocation of the total among the pools of the state then is accomplished by a mathematical formula which is provided for in the statute, and which is stated as follows:

"The respective pool classifications in their order from the smallest to the largest, will be allocated a daily rate of production in percentage on a descending scale, so as to result in a progressively increasing average allowed production in barrels per well from the smallest to the largest pool classification."

This means that each controlled pool must be classified according to the average potential of all its wells, and that a table of allowable percentages be so constructed that pools with the larger average potential will receive a lesser percentage but a greater allowable in barrels per day. The so-called "log-log curve" has been used for years to accomplish such distribution (see Fig. 1 and Table 1 for actual examples). It gets this name because a curve is drawn each month on double log paper, where the allowable percentage is plotted against the pool classification. The fixed point of the curve is at 15 bbl. and

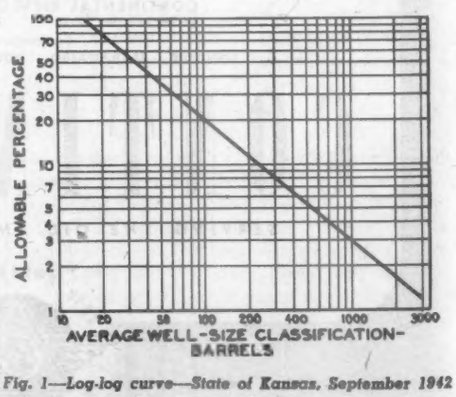


Fig. 1—Log-log curve—State of Kansas, September 1942

More Oil Needed for Victory

SURVEY OLD WELLS WITH "SURWEL"

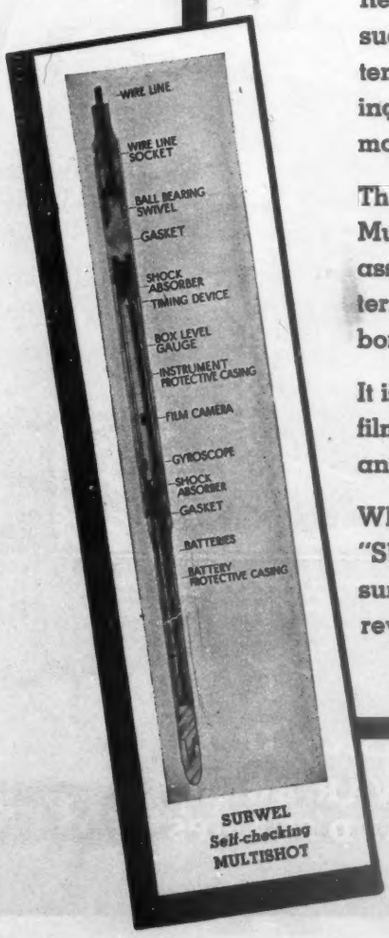
With the pressing need today for more oil, many an old well, drilled before the days of well surveys may become a fruitful source of oil.

Reconditioning or redrilling of such wells should not be attempted without first establishing the bottom hole location by making a "SURWEL" Survey

The "SURWEL" Gyroscopic Multi-shot Surveying Instrument assures the most accurate determination of the course of a bore hole in the shortest time.

It is *self-proving*, as it records on film the facts both when lowered and when withdrawn.

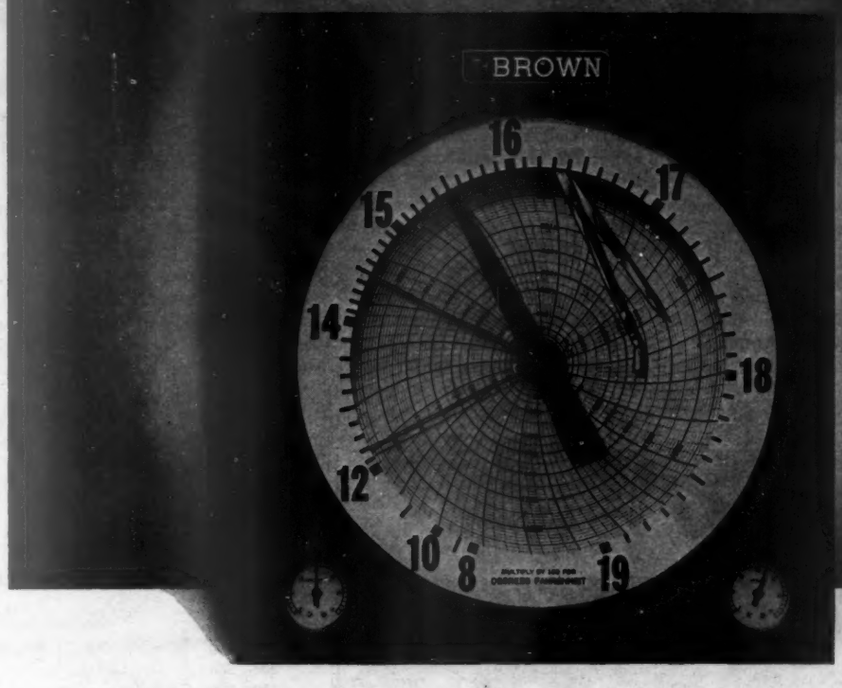
When a hole is surveyed with a "SURWEL" you have every assurance that the true facts are revealed.



SPERRY-SUN WELL SURVEYING CO.

1608 WALNUT STREET PHILADELPHIA, PA.

Houston, Corpus Christi, Odessa, Texas; Lafayette, La.; Long Beach, Bakersfield, Calif.; Oklahoma City, Okla.



THE Brown *"Continuous Balance" Air-o-Line* Potentiometer Controller is the culmination of more than three-quarters of a century of experience in the building industrial measurement and control instruments.

The experience of the past combined with the demands of today have resulted in a new potentiometer air-operated controller that will meet the needs of many future years.

In this radically new potentiometer controller a *"Continuous Balance"* Unit takes the place of the galvanometer used in the conventional mechanical-type potentiometer employing a periodic or cyclic mechanism.

It is the only potentiometer-type instrument in which the air control flapper mechanism is *instantly* positioned in response to temperature changes.

The *"Continuous Balance"* measuring system makes it possible to take full advantage of thermocouple responsiveness. Positive control action is assured by the well-known, dependable Brown *Air-o-Line* Control Unit, thousands of which are in service throughout industry.

The Brown Circular Chart *Air-o-Line* Potentiometer Controller brings to industry, for the first time, the ideal synchronization of measurement and control for temperature processes.

In the synthetic rubber war program engineers have approved this instrument as the ideal controller for the difficult fractionating problems in the manufacture of butadiene.

BULLETIN SENT ON REQUEST

Outstanding features such as: Control Unit—Throttling Range Dial—Automatic Reset Dial—Booster Pilot Valve—Control Index Knob—Direct and Reverse Action—Compression Type Fittings—Control By-Pass Panel—Balancing Motor—Slide Wire—Pen Arm Release—Chassis—are fully described in Bulletin 15-4. Write for it.

BROWN

"Continuous Balance"

POTENTIOMETER CONTROLLER

THE BROWN INSTRUMENT COMPANY, 4488 WAYNE AVE., PHILADELPHIA, PENNSYLVANIA
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.
MINNEAPOLIS, MINNESOTA AND 119 PETER STREET, TORONTO, CANADA
Wadsworth Road, Perivale, Middlesex, England
Nybrokajen 7, Stockholm, Sweden

100 per cent. From this point a declining straight line is drawn, and by trial and error it is placed in a position so as to give proper allowable percentages to all pool classifications of from 15 bbl. to 3,000 bbl. and still remain within the state allocation. Pools with wells averaging less than 15 bbl. daily are exempt from any restriction, and 3,000 bbl. is the maximum pool classification in use at present. It should be observed that the above operation is used only for pool allowables.

This type of system is adapted easily to Kansas, because the physical characteristics of the large majority of pools are very similar, and the demand and gathering facilities are distributed evenly over most the area of restricted production. In this connection, it is interesting to note that out of some 235 prorated pools there are only five minor isolated pools receiving special allowables.

After the pool allowables have been calculated by use of potential capacity and the "log-log curve" percentage factor, it becomes necessary to make the proper distribution to the various wells therein. The statute provides that no well may be restricted below 15 bbl. daily. The potentials of many wells, when multiplied by the pool percentage factor, will not result in an allowable of 15 bbl.; therefore, it is necessary to give such wells the 15-bbl. minimum and distribute the balance of the pool allowable among the higher potential wells in proportion to their potentials. This, too, is a matter of trial and error, until the proper adjusted percentage factor is found for each pool.

Since the adoption of the current law in 1929 the commission takes into consideration acreage attributable to wells in the allocation of production. This factor further modifies the procedure previously outlined. Ten acres is the basic acreage unit used in all formula calculations; however, full weight to acreage, up to 20 acres per well, is considered both in establishing the allowable for a given pool and in distributing the allowable production among the wells in the pool. In other words, one 20-acre well is equivalent to two 10-acre wells of the same capacity.

TABLE 1—STATE OF KANSAS—CLASSIFICATION TABLE
(September 1942)

Average well-size classification (ft.)	Normal allowable (per cent)
2,750-3,000	1.20
2,500-2,750	1.29
2,250-2,500	1.40
2,000-2,250	1.53
1,750-2,000	1.68
1,500-1,750	1.88
1,250-1,500	2.14
1,000-1,250	2.49
900-1,000	3.00
800- 900	3.28
700- 800	3.62
600- 700	4.04
500- 600	4.60
450- 500	5.36
400- 450	5.85
350- 400	6.45
300- 350	7.21
250- 300	8.20
200- 250	9.56
180- 200	11.51
160- 180	12.56
140- 160	13.86
120- 140	15.50
100- 120	17.63
90- 100	20.52
80- 90	22.41
70- 80	24.72
60- 70	27.64
50- 60	31.44
40- 50	36.60
30- 40	44.10
20- 30	56.07
15- 20	78.65

Note: These percentages are not used directly in calculating well allowables; instead an adjusted percentage is figured for each pool.

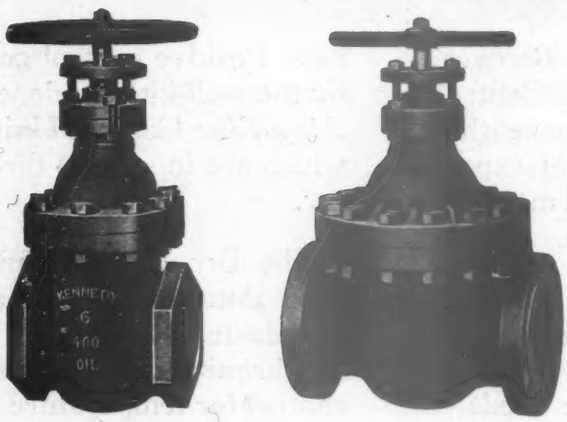
Since the adoption of federal Conservation Order M-68, the commission has revised its rules on acreage assigned so as to preserve a reasonable degree of equity in pools now being drilled on 40-acre spacing. For such 40-acre wells the rules now permit the assignment of as much as 30 acres, provided certain specified requirements are met concerning the location of the well in respect to unit boundaries and other producing oil wells.

Potentials generally are established by the "drawdown" or fluid-level method. The maximum allowed potential determined by such methods is 3,000 bbl. daily; however, there is no limitation on the size of the potential which may be established by restricted physical pumping tests or flowing tests. "Productivity" in Kansas means the potential of a well multiplied by its assigned acreage and then divided by the basic 10-acre constant. Thus the productivity may be as much as 9,000 bbl. if a 3,000-bbl. well is assigned 30 acres.

Kansas has no direct provision in the law regarding well spacing; however, with acreage playing such a major part in the allocation of production, the problem, as such, is of little importance. In the rules of the commission there is, likewise, no requirement for uniform spacing, but there are very definite restrictions regarding the shape of the unit and the location of the well thereon. The system, in other words, is based on the principle of flexible drilling units, with full weight to acreage in allocation.

The entire conservation program seems complicated and burdensome, but actually it works

There's SECURITY in every KENNEDY VALVE DESIGN



Security of operation . . . because the simple, sturdy, effective operating mechanism of these valves assures tight closure, prompt release on the first opening motion, and easy operation

Security against trouble . . . because the efficient design and heavy proportions of every part of these valves provide a more-than-generous margin of strength at rated pressures

Security of economy . . . because the long life and minimum maintenance expense of these valves have been proven in refineries, oil and gas fields, pump houses and high pressure oil and gas pipe lines all over the country.

You are SECURE when you install Kennedy Valves. For full description of their many advantageous features, write for the 240-page Kennedy Catalog.

THE KENNEDY VALVE MFG. CO. . . . . ELMIRA, N. Y.

KENNEDY
Extra Value in VALVES

smoothly and, in general, is considered one of the most advanced and best conducted systems.

Louisiana

The Louisiana conservation statute is enforced by the Minerals Division of the Department of Conservation through the director of minerals and five district managers. The commissioner of conservation is appointed by the governor for a term of 4 years, running concurrently with the governor's term of office.

Allowables are fixed monthly by the commissioner of conservation after evidence has been received in open hearing. Such hearings usually are held at 2-month intervals. In establishing the state allowable, the recommendation of the petroleum coordinator is given serious consideration, along with the firm nominations of the purchasers.

The distribution of the total state allowable to the various pools is based primarily on depth, quality of the crude, local market demand, and physical condition of the reservoir. When sufficient market exists and the question of underground waste is not involved, the average well allowable in any pool is determined by a sliding-scale depth formula (see Table 2). Special crudes

TABLE 2—STATE OF LOUISIANA—DEPTH FORMULA
(September 1942)

Depth (ft.)	Type 1 (high octane crudes)	Type 2 (medium octane crudes)	Type 3 (low grade and unclassified)
0- 2,000	54	45	41
2- 3,000	69	54	50
3- 4,000	82	65	60
4- 5,000	97	77	71
5- 6,000	114	90	84
6- 7,000	132	106	98
7- 8,000	151	122	111
8- 9,000	172	138	126
9-10,000	194	156	144
10-11,000	219	176	162
11,000+	245	197	182

Note: Type 1 is average of 24 per cent higher than Type 2; Type 3 is average of 8 per cent lower than Type 2.

used in the manufacture of aviation gasoline and other war materials are given a preferred position above the regular crudes in this formula. The formula changes from month to month, depending on state allowable, demand for preferred crudes, and the number of producing wells. All wells are subject to gas-oil-ratio limitation, either by state-wide order or special pool regulation. That portion of the allowable assigned to wells that cannot be produced by them, or of wells whose allowable is reduced due to excessive gas-oil ratio, is reallocated to other wells in the pool which can produce it. In this way allowable once granted to a pool is never lost by redistribution to other pools in the state.

When feasible, rules and regulations are set up in each pool to govern well spacing, development and completion practices, control of reservoir energy, and the method of allocation. These rules are established after interested operators have made recommendations to the commission at open hearing.

The matter of distributing production to wells within the pool naturally varies from pool to pool according to the rules in effect. Various factors and combination of factors are used because of the great differences in types of reservoirs. For instance, 50 per cent acreage plus 50 per cent potential is used at Anse La Butte and Barataria, whereas straight acreage is used in the La Salle and Catahoula area. On the other hand, either bottom-hole pressure plus acreage, or bottom-hole pressure times acreage, is the customary formula in North Louisiana. Variations of the above basic formulas may be found throughout the state, depending on local conditions. Well potentials, when used, usually are restricted by the use of small-size chokes.

Piercement-type salt domes and complex faulted structures in the Gulf Coast area usually have special treatment with respect to spacing and allocation. Because of the individual nature of such reservoirs, it is considered inadvisable to require wide and uniform spacing. As a result, most pools of this type have been developed on a rather close and irregular pattern, with the allocation based mostly on a potential or flat well.

The permitted acreage assignment to oil wells varies from 5 to 80, with the big majority being 40. Most rules require that the well be located approximately in the center of the unit, except in the case of 80-acre rectangular development. In such cases the well locations must be in the center of staggered 40-acre squares. Spacing exceptions are not needed in the case of small and irregular-shaped tracts, as the commission is authorized by law to require the unitization of small tracts in order to form a full proration or drilling unit.

Recycling in gas-distillate reservoirs is looked upon with much favor in Louisiana; and, in order to attain proper results from such operations, the commission may order the complete unitization of reservoirs of this nature.

Due to the many different types of reservoirs, it is evident that considerable flexibility is necessary in allocation and conservation methods. In general, the Louisiana system is considered reasonable and well advanced, both from a scientific and equitable standpoint. For the most part, spac-

THE DURAMETALLIC TWIST

1. Processed to retain lubrication.
2. Provides readier response to gland pressure.
3. Distributes frictional load over several diagonally wrapped metallic sheets.
4. Originated by DURAMETALLIC.

THERE'S A WAR TO BE WON!

Pump room performance is important! This is no time to handicap the efficiency of your pumps with make-shift packing . . . specify DURAMETALLIC twisted, flexible metallic packing and be assured of long runs, better sealing and friction-free service.

Write Today for

SPECIFIC RECOMMENDATIONS ON THE RIGHT TYPE PACKING FOR YOUR NEEDS

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

The PERFECT SEAL

HOUSTON • LOS ANGELES • CHICAGO • NEWARK • NEW ORLEANS • DETROIT • SAN FRANCISCO
SEATTLE • TULSA • MONTREAL • YOUNGSTOWN, O. • FREDERICKSBURG VA. • KANSAS CITY • MINNEAPOLIS

ing restrictions under federal Conservation Order M-68 have not affected materially the drilling program or the allocation of production in this state.

Michigan

The Michigan conservation law is administered by the Department of Conservation, through a director of conservation and an advisory board. The Conservation Commission consists of seven members, appointed by the governor and confirmed by the senate for staggered 6-year terms. The director of conservation, who is also supervisor of wells, in turn is appointed by the Conservation Commission. The supervisor of wells, with the approval of the Conservation Commission, appoints a six-man advisory board, three of whom must be chosen from independent oil producers, and three represent major companies—all residents of the state. Before issuing or revoking any rule, regulation, or order, the supervisor of wells must consult with and receive the recommendation of this advisory board. After meeting this formality, the supervisor of wells is free to act according to his best judgment in proration and conservation matters, as there is nothing in the law compelling him to follow such board's advice. The Conservation Commission acts as an appeal board on complaints against the decision of the supervisor of wells. Both the Conservation Commission and the advisory board members serve without salary.

On the whole, this seemingly complex administrative setup works very smoothly and effectively. Credit for this, no doubt, is due to the supervisor of wells and his capable staff of experts.

The state's monthly allowable, as required by law, is determined after a careful survey of market and reservoir conditions has been made on each pool. The need for Michigan crude bears great weight in the establishment of allowables, both from a state-wide and a pool basis, provided the recommendation of the petroleum coordinator is not exceeded. There is no formula for distributing allowables to the various pools in the state, as only physical waste and local market demand are the controlling factors in the establishment of pool allowables. The proper rate of flow is considered most seriously for each pool at the regular monthly hearings. The state allowable then is determined after a careful study of such evidence.

Prior to federal Conservation Order M-68, rectangular 20-acre uniform drilling units were established in most prorated pools. The law requires that wells be located in the center of drilling units so far as is practicable. The distribution of allowable among wells in a pool is calculated on a unit basis, and in effect means full acreage allocation. The allowable to wells drilled on small tracts, as exceptions to the established plan of development, is adjusted downward on a direct acreage basis. On the other hand, properties are protected from undue drainage when wells are located on 40-acre units because of compliance with federal Conservation Order M-68, by the application of an adjustment factor. This factor automatically gives a 40-acre well 175 per cent of the allowable of a 20-acre well in the same pool. An adjustment of this nature is considered very reasonable for reservoirs partly developed on a closer plan of spacing before the war emergency.

Although conservation and proration are relatively new in Michigan and controlled reservoirs are few in number, the state ranks high in system and administration.

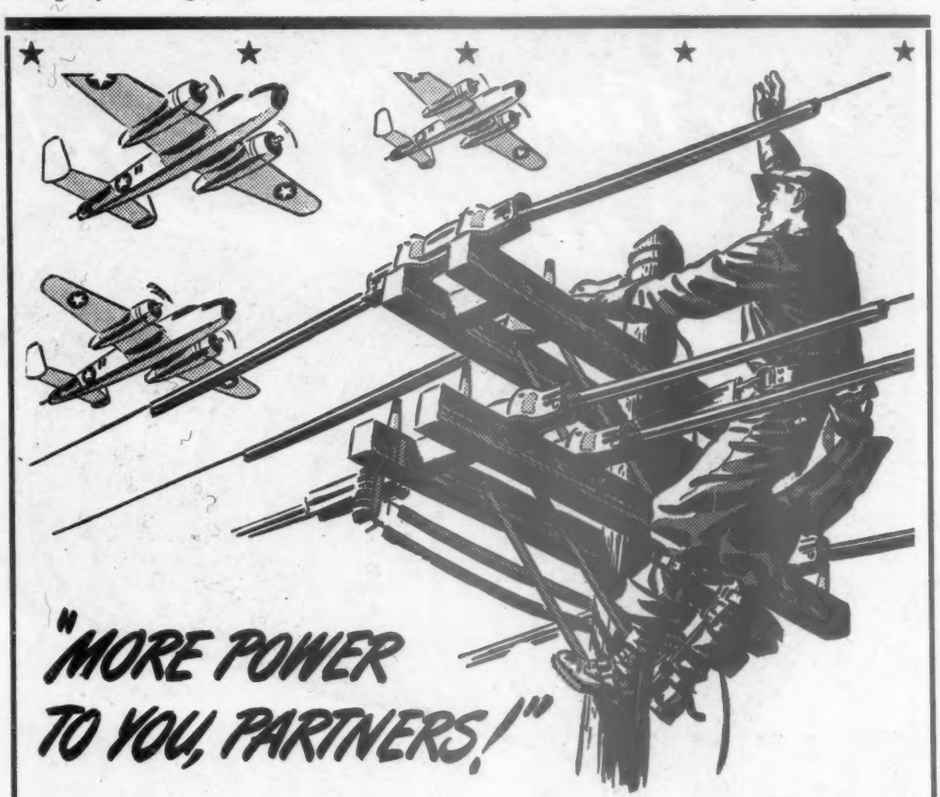
New Mexico

The conservation statute of this state is administered by the Oil Conservation Commission, consisting of the governor, commissioner of public lands, and the state geologist. The governor and the land commissioner are elected for 2-year terms, and the state geologist is appointed by the governor for a like 2-year period. The state geologist serves as secretary of the commission, and in such capacity has direct charge of the conservation-department organization.

Proration in New Mexico, both as among the pools of the state and among the wells within a pool, is extremely simple. Uniform 40-acre proration units have been in effect for years, and each such unit receives the same allowable irrespective of the number or quality of wells thereon. The only restriction as to the spacing of the well on the unit is that wells must not be located closer than 330 ft. from the unit boundaries. The actual mechanics of distributing allowables is likewise very simple. First the total state demand is determined each month after a careful review has been made of the market situation, and after due consideration of the petroleum coordinator's recommendation. Then each 40-acre unit in the state which is incapable of making the full unit allowable is assigned that amount which it is capable of producing. The remaining portion of the total state allowable finally is distributed equally among all the remaining 40-acre units in the state which are capable of producing their allowables.

Due to special reservoir conditions in the Hobbs and Monument pools, a slight variance in method of distribution is used: in these a 20 per cent adjustment is made by using bottom-hole pressure. A gas-oil-ratio rule is established for each prorated pool, and as a result gas wastage is held to a minimum. The commission, through its technical staff, constantly is checking reservoir conditions, so that waste in any form might be detected and corrective measures taken when needed.

New Mexico's unified and simplified system of proration has proved satisfactory over the years. In general, drilling has been done on a "well to 40-acre basis"; full weight to acreage has predominated in allocation formulas, and waste of



"MORE POWER TO YOU, PARTNERS!"

WE'LL keep things humming down here while you're fighting up there.

We'll see to it that there's plenty of electricity at every switch at the air field—and plenty of power for the production lines that are pouring out airplanes, tanks, guns, supplies and ships.

That takes a *lot* of electric power—*but we've got what it takes!* We have *far more power* than *all* Japanazis—*five times as much* as we had in the last war!

American business management is producing ⅞ of that flow of power. The same practical business management under public regulation that has *increased* electric service and *decreased* electric prices so much that the average American family today enjoys about *twice as much electricity* for the same amount of money it did 10 to 15 years ago.

More power to you, partners! Once this war's won, we'll provide the power to build a better world!

SOUTHWESTERN
GAS AND ELECTRIC COMPANY

reservoir energy prevented. With these conditions prevailing, federal Conservation Order M-68 has had little, if any, effect in this state.

Oklahoma

In Oklahoma the conservation statute is administered by the Corporation Commission of Oklahoma, through the conservation officer of the Oil and Gas Division. The commission consists of three members, elected for staggered 6-year terms.

The law provides that market demand must be considered in determining whether production can be made without waste. Under this system the nomination of the purchasers, made in good faith, bear great weight in determining pool allowables. The state market demand then is deemed to be the aggregate of all individual pool nominations. Due to the extensive network of pipe lines throughout the state and the strong local and adjacent market, the demand for Oklahoma crude is relatively high. However, the recommendations of the petroleum coordinator are followed closely each month.

Hearings are conducted each month to determine both the allowable for the state and for the individual curtailed pools therein. No usable relationship between pools has been found; therefore, for that reason, each reservoir is considered individually from a standpoint of market and underground waste.

The only method of allocation among wells in a pool, as specified by the statute, is "percentage of the potential," which means that, when restriction of production is necessary, then such curtailment should be proportional to the capacities of wells to produce. This antique method is not being currently followed entirely by the commission. Through several years of trial and error, many voluntary agreements have been reached, based on better methods of allocation; so that now most production in the newer pools is being distributed on a unit basis (as of October 1942).

Oklahoma has three general plans of allocation in effect at the present time, outlined as follows:

1. Proration on an individual-well potential basis; i.e., potentials are established for each well, and a separate allowable calculated for each well by using the well potential and the percentage factor for the pool. A minimum well allowable also is established in such pools, which is either the statutory 25 bbl. or a somewhat higher figure, based on conditions in the particular pool. The Oklahoma City Wilcox pool is the outstanding example of this type.

2. Proration on a lease potential basis, where both the potential and allowable are calculated for all wells on a lease as a group. A minimum lease allowable usually is set for this type of production. Pools in the Seminole and Fitts area are on this basis.

3. In newer reservoirs, potential systems are dispensed with entirely, and a simple but effective flat-well allocation plan is used. In effect, this actually means unit allocation, as uniform spacing prevails.

The law does not provide specifically for acreage as a direct allocation factor in the distribution of production; however, the law does give the commission authority to establish uniform drilling units in any reservoir and to require that wells be located in the center of such units. Exceptions as to size of unit or location of well are permitted only after special hearing, at which time proof must be submitted to show that a regular location most likely would result in non-production. To protect offsets from drainage, the allowable on such wells is reduced in proportion to the size of the relative units.

The outstanding weakness in the Oklahoma well-spacing law is the provision that at least 80 per cent of the owners of leases, covering not less than 80 per cent of the probable productive area in a pool, actively approve any plan of development which provides for greater than 10-acre spacing. This burdensome limitation has done much to perpetuate relatively close spacing throughout the state. As a result only a few 40-acre spacing orders were adopted prior to federal Conservation Order M-68. The commission, however, is attempting to prevent undue drainage in those partly developed reservoirs now being drilled on a 40-acre plan by adjusting allowables on flat acreage basis. In general, the Oklahoma operator has found it somewhat difficult to switch to 40-acre spacing so abruptly.

Although proration and conservation were pioneered and developed to a great extent in Oklahoma, the current methods are not as effective as they could be—probably due to the fact that production is predominantly of the stripper type, with very few reservoirs of major magnitude being discovered which demand more detailed state control. The commission encourages efficient operation and control of every possible reservoir, and operators practicing such methods in good faith are permitted much leeway in order that the best results may be accomplished.

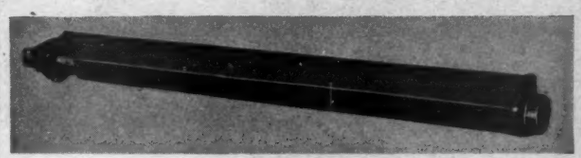
Texas

Conservation and proration in Texas are administered by the Railroad Commission of Texas, which consists of three members, elected for 6-year terms, terminating at 2-year intervals. Its orders and regulations are enforced by the chief supervisor of the Oil and Gas Division. The commission is permitted wide discretionary powers under the law and, consequently, has originated many revolutionary policies and systems.

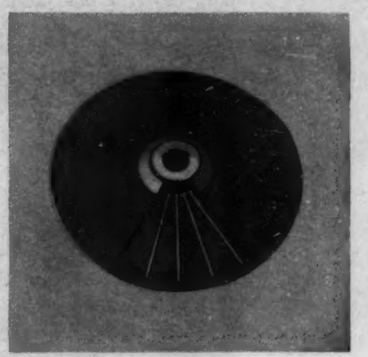
Allowables are established each month after

(Continued on Page 172)

Cut-away Teardrop Diffuser Element.



Cut-away Type "A" Diffuser Element.

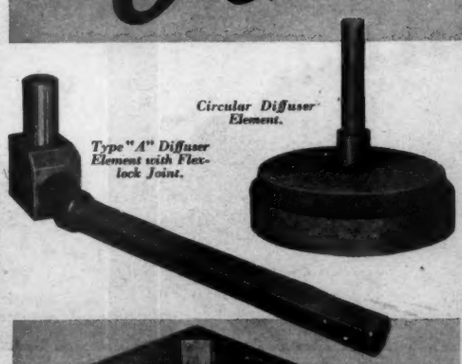


Porous Carbon Filter Leaf.

RESISTANT TO CORROSION AND THERMAL SHOCK

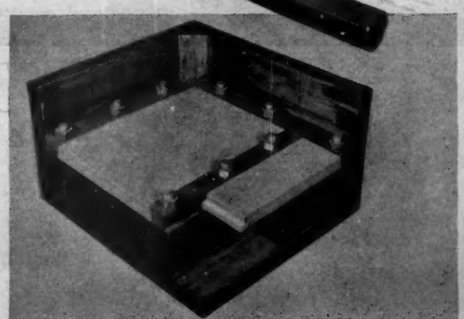
EASILY MACHINED AND FABRICATED

AND *Porous!*



Circular Diffuser Element.

Type "A" Diffuser Element with Flex-lock Joint.



Section of "Karbate" Filter Tank with Porous Carbon False Bottom.

● National Carbon Company, Inc. now includes in its list of standard products a line of porous carbon and graphite materials designed for filtration and gas diffusion applications. These materials possess the same advantages which have made carbon, graphite and "Karbate" materials so successful in the construction of chemical equipment for the process industries. Properties are chemical inertness, exceptional resistance to thermal shock, and ease of machining, which permits fabrication of apparatus as desired for specific applications.

Several grades of porous carbon and graphite of different degree of porosity cover a wide range of permeability. High permeability, small pore size and uniform structure are combined in these materials.

Data on the permeability of these porous materials for all filtration and diffusion applications will be supplied upon request. A suitable grade to meet your requirements is available.

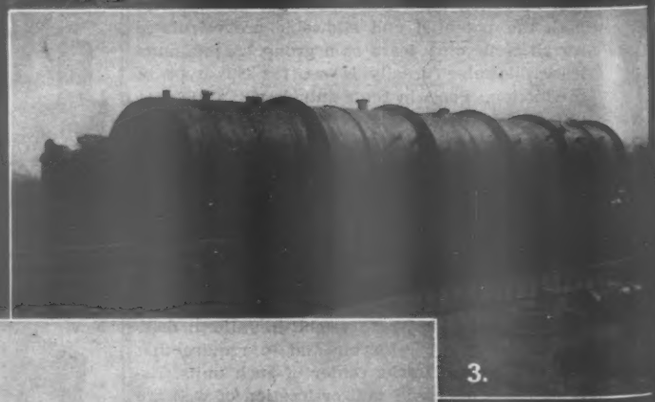
NATIONAL
TRADE-MARK
POROUS CARBON AND GRAPHITE
FOR FILTRATION, GAS DIFFUSION AND OTHER APPLICATIONS

Write for YOUR COPY OF CATALOG SECTION M-8900. THIS BULLETIN GIVES FULL INFORMATION ON THESE POROUS MATERIALS

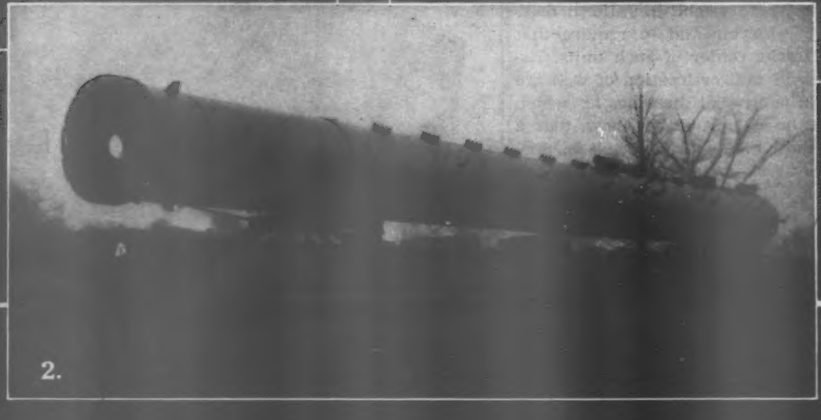
NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
UCC
CARBON SALES DIVISION, CLEVELAND, OHIO
General Offices: 30 East 42nd St., New York, N. Y.
Branch Sales Offices: New York, Pittsburgh, Chicago, St. Louis, San Francisco

PRESSURE VESSELS

1.



3.



2.

Among the units which have been fabricated for the oil industry to meet specific requirements are: Bubble Towers, Fractionating Columns, Cracking Chambers, Polymerization Towers, Accumulators, Butane and Propane Tanks, Evaporators, Oil Stills, Reaction Chambers, Absorber Towers, Flash Towers, Reforming Towers, Reflux Towers, Stripping Towers and pressure or vacuum vessels for all purposes.

to solve a wartime problem

THE present world conflagration has placed before industry many complicated problems. In the petroleum field the nation's refineries are faced with the responsibility of producing increasing quantities of high octane fuels, butadiene, lubricants and numerous other essential petroleum products. Welded steel pressure vessels, such as those shown here, are helping refineries to sustain today's tempo of production.

It is natural for the petroleum industry to turn to *specialists* in the field of pressure vessels. Here, at Chicago Bridge & Iron Company, the designing and fabricating of units to meet specific oil industry requirements is an old story. Plant facilities for handling difficult welding and fabrication, including radiographing and stress-relieving, are complete in every detail. Strict inspection during every step of fabrication helps to assure efficient and economical units when installed at the refinery.

1. *A 10 ft. 6 in. diam. by 58 ft. 9 in. fractionator tower fabricated for a Louisiana refinery. It has a cone bottom with a special welded connection.*

2. *Two flat cars were required to ship this 86-ft. debutanizer tower (5 ft. 6 in. in diam.) to the Texas refinery for which it was fabricated.*

3. *The vacuum flash column shown in this view measures 8 ft. 6 in. in diam. by 50 ft. It was fabricated for a refinery in Kentucky.*

4. *This vessel is 7 ft. 6 in. in diam. by 85 ft. 5 in. long. It was stress-relieved in two heats, by placing first one end, and then the other, in the furnace.*

CHICAGO BRIDGE & IRON COMPANY

BIRMINGHAM • CHICAGO • CLEVELAND • DETROIT • HAVANA • HOUSTON
NEW YORK • PHILADELPHIA • SAN FRANCISCO • TULSA • WASHINGTON

(Continued from Page 169)

evidence has been received in open hearing. Purchaser nominations, the recommendation of the petroleum coordinator, the demand for special crudes used in the manufacture of war materials, and the physical condition of the various reservoirs all carefully are studied before the total state allowable is established.

Early in 1941 the commission adopted a "yardstick" formula for distribution of total state allowable to the various pools on a definite relationship. The avowed purpose of the play was to prevent "selective buying"—the theory being that the total state demand should be shared by all pools, producing similar types of crude, on some fixed equitable basis. Quality of crude, depth of production, and attributable acreage are the principal factors used in the formula. The value of these factors does not remain identical over the entire state, but varies according to basic conditions in the different geographical areas (see Table 3 for details). From the inception of the plan most operators and purchasers accepted the "yardstick" as being quite reasonable. A few objecting operators met defeat in court actions aimed at its nullification. On the other hand, the war emergency, in recent months, has caused some drastic changes in the application of the formula. However, the basic principle of the "yardstick" is being retained whenever possible for the establishment of the allowable of the pools.

The logical plan to follow in a system of this nature would be to establish the total allowable for the state and then distribute the total state allowable among the various areas and pools according to the formula. In Texas this procedure is not followed exactly. Instead, a theoretical "basic" daily allowable, considerably in excess of the actual market demand, is distributed among the pools on the "yardstick" formula. Then, in order to hold the state's actual monthly production to the market demand, certain shutdown days are ordered in the various pools. The practice of requiring shutdown days originated several years ago when it was considered illegal to restrict the "schedule" daily allowable for any

TABLE 3—STATE OF TEXAS—YARDSTICK FORMULA
Crude Classifications

Mirando type	gasoline content below 10 per cent
Low-octane	gasoline content above 10 per cent and octane number below 50
Intermediate-octane	gasoline content above 10 per cent and octane number between 50 and 60
High-octane	gasoline content above 10 per cent and octane number above 60
Low cold-test	heavy crudes—Gulf Coast area with low cold test lube fractions

SOUTHWEST, GULF COAST, AND EAST TEXAS
(Except East Texas Field)

Depth (feet)	Mirando	Low octane	Intermediate octane	High octane	Low cold test
0- 1,000	10	..	..	..	..
1,000- 1,500	15	..	..	..	..
1,500- 2,000	20	10	15	20	25
2,000- 3,000	25	15	20	25	30
3,000- 4,000	30	20	25	30	35
4,000- 5,000	35	25	30	35	40
5,000- 6,000	40	30	35	40	45
6,000- 7,000	..	35	40	45	50
7,000- 8,000	..	40	45	50	55
8,000- 8,500	..	47	52	57	62
8,500- 9,000	..	52	57	62	67
9,000- 9,500	..	60	65	70	75
9,500-10,000	..	74	79	84	89
10,000-10,500	..	95	100	105	110
10,500-11,000	..	125	130	135	140
11,000-11,500	..	155	160	165	170

(10-acre base. Add 1 bbl. per acre for wells on larger units)

NORTH AND WEST CENTRAL TEXAS
(Classed as Intermediate)

Depth (feet)	Mirando	Low octane	Intermediate octane	High octane	Low cold test
0- 1,000	..	..	10	..	..
1,000- 2,000	..	..	15	..	..
2,000- 3,000	..	..	20	..	..
3,000- 4,000	..	..	25	..	..
4,000- 5,000	..	..	30	..	..
5,000- 6,000	..	..	35	..	..

(10-acre base. Add 1 bbl. per acre for wells on larger units)

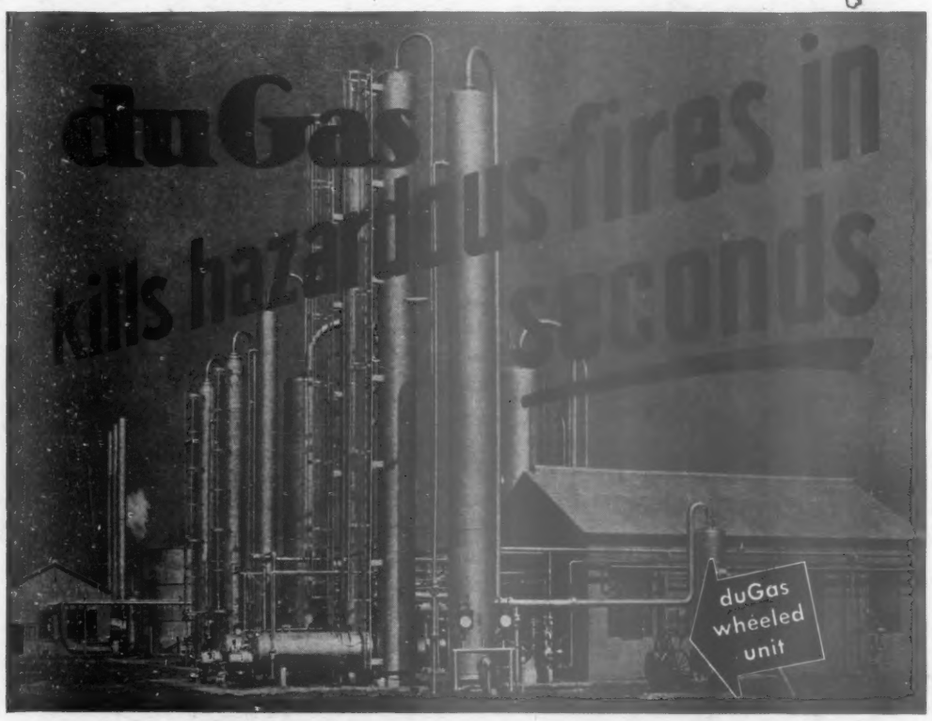
WEST TEXAS
(Classed as Low-Octane Sour Crude)

Depth (feet)	Mirando	Low octane	Intermediate octane	High octane	Low cold test
0- 1,000	..	10	..	..	..
1,000- 2,000	..	15	..	..	..
2,000- 4,000	..	20	..	..	..
4,000- 6,000	..	25	..	..	..
6,000- 8,000	..	30	..	..	..
8,000+	..	35	..	..	..

(An additional 0.5193 bbl. is allowed for each assigned acre)

Note: The East Texas field and the Panhandle field are treated individually in the establishment of allowables.

BOMBS OR SABOTEURS MAY NEVER REACH YOU... BUT ARE YOU *Ready?*



● **Fires—from whatever source—are no longer just company losses. They are *national* losses. They are *victories for the enemy*.**

DuGas fights fires with the speed and killing action of an armored division. DuGas, always ready for battle action, cuts priceless seconds from the extinguishing period.

DuGas, on guard at refineries, wells, and pumping stations across the nation*, is particularly effective on fires in highly inflammable liquids and gases under pressure. *Names on request.

duGas

Fire Extinguishing Apparatus

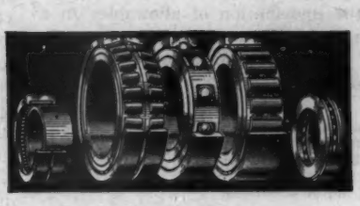
DUGAS ENGINEERING CORPORATION, Marinette, Wisconsin

REPRESENTED IN PRINCIPAL CITIES *OWNED AND OPERATED BY ANSUL CHEMICAL COMPANY*

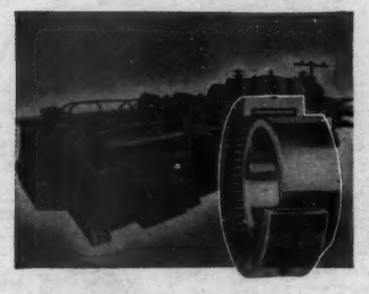
Approved by UNDERWRITERS' LABORATORIES, FACTORY MUTUAL LABORATORIES

IN THE NEWS
WITH BANTAM BEARINGS

ON THE 1000-POUND LANDING GEAR of many giant bombers, you will find Bantam Needle Bearings contributing to smooth, dependable operation of the "Up-Latch" which locks the gear in flight position. This is just one of the ways that the many types of Bantam Bearings are helping to assure the successful functioning both of the weapons for Victory and of the machines that produce them.



BANTAM'S ENGINEERING COOPERATION is especially valuable in meeting new and unusual requirements. Bantam makes every major type of anti-friction bearing—straight roller, tapered roller, needle, and ball. Bantam engineers aid in the selection of the most suitable type, or design special bearings to meet your requirements. If you have a difficult bearing problem, TURN TO BANTAM.



SPEED AND ACCURACY characterize the operation of centerless bar turners built by The Medart Company and used for precision finishing of bars and tubular products. In an ingenious feeding device combining hydraulic and mechanical action, standard Bantam Quill Bearings serve a novel application in cam rollers on the feeding grip jaws.

RIGID LABORATORY CONTROL contributes to the successful performance of Bantam Quill Bearings—the unusual anti-friction bearings that combine high radial load capacity, small size, ease of installation and lubrication. Samples from daily production runs are regularly tested for adherence to metallurgical and machining specifications. For further information on the Quill Bearing, write for Bulletin J-104.

OIL FOR A WAR OF MACHINES is needed in ever-increasing quantities—and the drill bits are turning faster, boring deeper into the earth. This cut-away view shows one of The Wheland Company's High-speed Oil Bath Rotaries, designed to meet every requirement of present-day drilling practice—and large Bantam Precision Ball Bearings are used to take both thrust and radial loads on the rotary table.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

well to a point below the limits set out in the marginal-well law.* Now the "shutdown" days are utilized to adjust allowables so as to minimize inequities in the distribution of allowed production and at the same time meet both the local and state demand. This system affords great flexibility in the distribution of allowables in a state proration system so complex in nature. To illustrate this point, the September 1942 order provides for seven different "shutdown" schedules, in addition to the 102 fields completely exempt from shutdowns.*

The distribution of the pool allowable to the various wells and properties is based upon the rules and regulations in effect for the particular reservoir. It is the custom in Texas to have individual-pool rules and regulations, covering such items as well spacing, proration units, allocation formula, and gas-oil-ratio restrictions. Such rules are adopted after hearing, at which time all operators have an opportunity to make recommendations. Naturally, many different types of allocation formulas are provided for in these pool regulations. In some cases the pool allowable is divided equally among the wells, whereas in others the distribution is on a straight acreage basis. Many pools have a split formula consisting of 50 per cent acreage plus well potential, bottom-hole pressure or even flat well for the other 50 per cent. In rules most recently adopted there seems to be a strong inclination to adopt the simple but effectiveness formula based upon 75 per cent acreage plus 25 per cent well.

In some of the older pools the minimum or marginal-plus plan of allocation is still used. When this is the case, it usually results in the minimum part of the allocation consuming most of the pool allowable. Under this plan neither acreage, bottom-hole pressure, nor potential is of much importance in the final distribution. This condition is particularly true in the East Texas and Panhandle fields. It might well be observed that this method of allocation in these fields has resulted in the drilling of thousands of unnecessary wells and in a most inequitable distribution of recoverable oil.

The Railroad Commission of Texas in recent years has recognized the problem of the unnecessary well to a great extent, and is helping solve it by the approval of many wider individual spacing plans. The general state-wide rule on spacing also was increased from 2.07 acres per well to 20 acres about 2 years ago. The same rule more recently has been changed to require 40-acre spacing in conformity with federal Conservation Order M-68. These efforts, although important, have not been sufficient to correct the disparity caused by the operation of Order M-68 in fields partly developed before December 23, 1941.

Most inequities of distribution in Texas arise from two weaknesses in the system: one being the failure to compel unitization of small tracts to form regular drilling units, and the other the liberality in granting exceptions to the well-spacing rules. It is obvious that, if the value of acreage had been stressed more in the allocation of production, the unfavorable results probably would be less pronounced today.

Commission engineers constantly are checking reservoir conditions throughout the state in an effort to promote the best possible conservation. The discovery of new reserves is recognized by the commission as essential, and encouragement in this direction is evidenced by a liberal discovery allowable.

The entire Texas system is naturally complex due to the many different types of reservoirs and other local peculiarities. Almost every conceivable plan of allocation is used to some extent, even those of 12 years ago. Some are reasonable and constructive, whereas others are inequitable and out of date. The trend, however, seems to point toward general improvement. In this state, due to its limited market outlet and

*The marginal-well law provides unrestricted production for pumping wells incapable of producing in excess of certain daily volumes averaged over a 30-consecutive-day period. These volumes vary according to the following depth schedule:

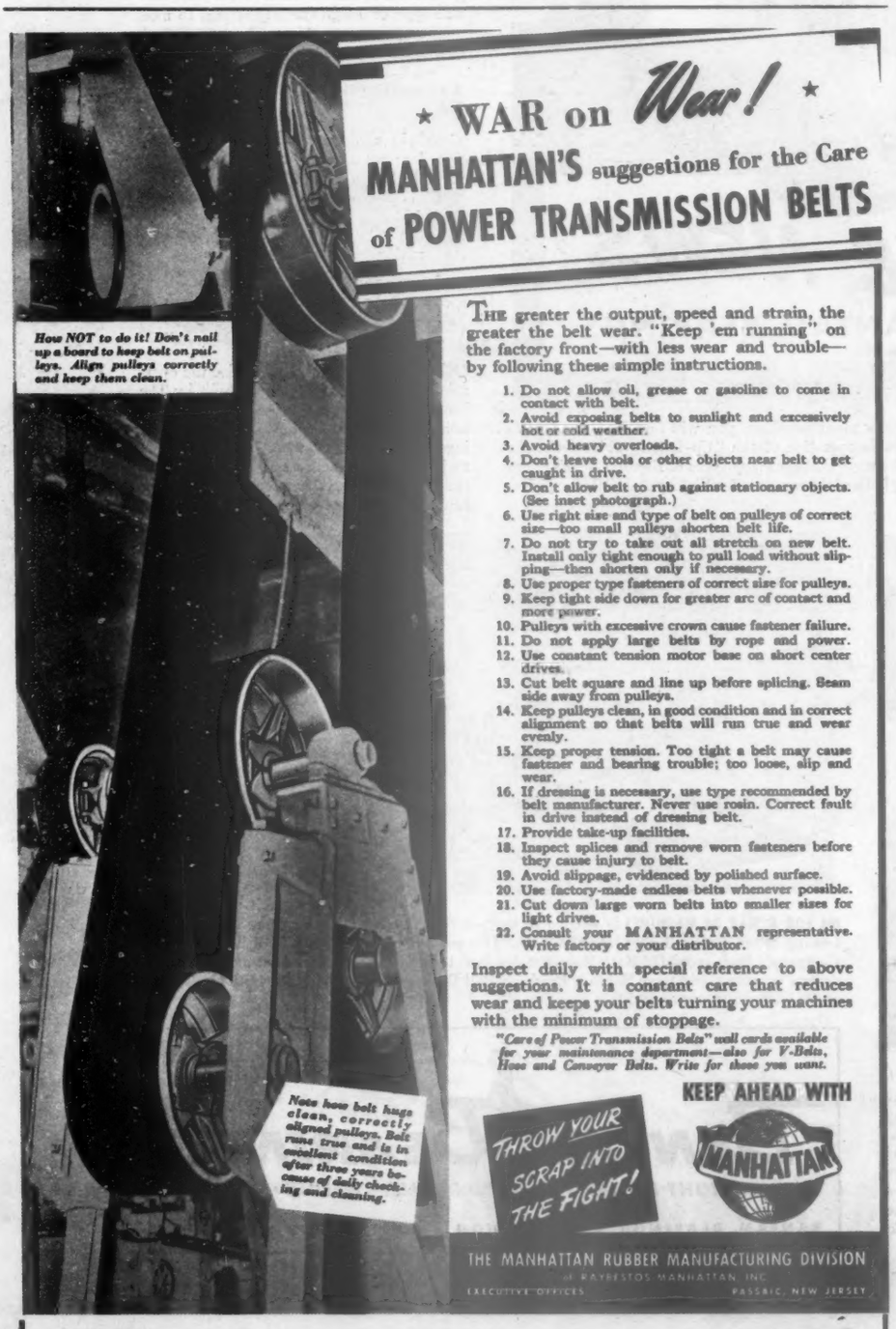
Depth (feet)	Unrestricted daily allowable (bbl.)
2,000 or above	10 or less
2,000-4,000	20 or less
4,000-6,000	25 or less
6,000-8,000	30 or less
Below 8,000	35 or less

*More than 730 prorated pools scattered over entire state.

TABLE 4—STATE OF TEXAS—DISCOVERY ALLOWABLE SCHEDULE

Depth (feet)	Daily allowable (bbl.)
0- 1,000	20
1,000- 2,000	40
2,000- 3,000	60
3,000- 4,000	80
4,000- 5,000	100
5,000- 6,000	120
6,000- 7,000	140
7,000- 8,000	160
8,000- 9,000	180
9,000-10,000	200
10,000-11,000	220
11,000-12,000	240

Note: These allowables apply only to wells in newly discovered pools, and such application is limited to a period of 1 year after the completion of the discovery well or until the sixth well in the common reservoir has been drilled and completed.


How NOT to do it! Don't nail up a board to keep belt on pulleys. Align pulleys correctly and keep them clean.
Note how belt runs clean, correctly aligned pulleys. Belt runs true and is in excellent condition after three years because of daily checking and cleaning.

★ WAR on Wear! ★

MANHATTAN'S suggestions for the Care of POWER TRANSMISSION BELTS

THE greater the output, speed and strain, the greater the belt wear. "Keep 'em running" on the factory front—with less wear and trouble—by following these simple instructions.

1. Do not allow oil, grease or gasoline to come in contact with belt.
2. Avoid exposing belts to sunlight and excessively hot or cold weather.
3. Avoid heavy overloads.
4. Don't leave tools or other objects near belt to get caught in drive.
5. Don't allow belt to rub against stationary objects. (See inset photograph.)
6. Use right size and type of belt on pulleys of correct size—too small pulleys shorten belt life.
7. Do not try to take out all stretch on new belt. Install only tight enough to pull load without slipping—then shorten only if necessary.
8. Use proper type fasteners of correct size for pulleys.
9. Keep tight side down for greater arc of contact and more power.
10. Pulleys with excessive crown cause fastener failure.
11. Do not apply large belts by rope and power.
12. Use constant tension motor base on short center drives.
13. Cut belt square and line up before splicing. Beam side away from pulleys.
14. Keep pulleys clean, in good condition and in correct alignment so that belts will run true and wear evenly.
15. Keep proper tension. Too tight a belt may cause fastener and bearing trouble; too loose, slip and wear.
16. If dressing is necessary, use type recommended by belt manufacturer. Never use rosin. Correct fault in drive instead of dressing belt.
17. Provide take-up facilities.
18. Inspect splices and remove worn fasteners before they cause injury to belt.
19. Avoid slippage, evidenced by polished surface.
20. Use factory-made endless belts whenever possible.
21. Cut down large worn belts into smaller sizes for light drives.
22. Consult your MANHATTAN representative. Write factory or your distributor.

Inspect daily with special reference to above suggestions. It is constant care that reduces wear and keeps your belts turning your machines with the minimum of stoppage.

"Care of Power Transmission Belts" wall cards available for your maintenance department—also for V-Belts, Hose and Conveyor Belts. Write for those you want.

KEEP AHEAD WITH

THROW YOUR SCRAP INTO THE FIGHT!

MANHATTAN

THE MANHATTAN RUBBER MANUFACTURING DIVISION
of RAYBESTOS-MANHATTAN, INC.
EXECUTIVE OFFICES PASSAIC, NEW JERSEY

DISTRIBUTORS

In All Oil Fields Except California
THE NATIONAL SUPPLY COMPANY

In the California Oil Fields
HOWARD SUPPLY COMPANY
5125 Santa Fe Ave., Los Angeles, Calif.

Oil Tool Manufacturers' Secret Weapon...

the "Know How" in a machine age war

DOING the impossible is the every-day experience of oil tool manufacturers. It, therefore, did not astound executives of these companies to be asked to rearrange their plants, tool up, manufacture, and deliver implements of war on "impossible" schedules. That so many of them are doing this along with other manufacturers throughout the nation is proof that the Axis war lords miscalculated the power of the United Nations' secret weapon . . . the "know how" in a machine age.

Here at Mission it is our privilege to bring both speed and precision to war work . . . speed learned in meeting the requirements of the fastest moving of all industries, oil . . . precision learned in manufacturing Mission products to extremely close tolerances.

When peace comes and the oil industry is forced to greatly expand to take its share of America's bigger place in the world of industry, oil men will find at Mission the same progressiveness in the design of oil industry products that has made it a leader. In the meantime, we want you to call on us for ways of making the Mission tools you now have give better performance and longer service.

MISSION
MANUFACTURING CO.
HUMBLE ROAD HOUSTON, TEXAS

●

MANUFACTURERS OF:

MISSION SLUSH PUMP VALVES MISSION SLUSH PUMP PISTONS
MISSION PISTON RODS MISSION GLAND PACKINGS
MISSION ROTARY SLIPS MISSION SWABS MISSION PLUG VALVES

its magnitude of reserves, the problem is tremendous in scope.

Other States

Considerable new production has been developed in recent years in such states as Illinois, Mississippi, Wyoming, and Nebraska. However, nothing of consequence is being done in these states toward effective conservation.

Illinois has a so-called conservation statute which provides for elaborate and complicated spacing restrictions. The authority to limit production to market demand is expressly denied. It likewise is contended that curtailment of production for reservoir-waste prevention also is denied, and the fact remains that nothing is being done in this state toward conservation and proration.

Mississippi has a reasonably good conservation statute, but the state authorities disregard it, and production remains uncontrolled. Other oil-producing states either lack conservation laws or have settled production not in need of curtailment.

Interstate Oil Compact Commission

The states of Texas, Oklahoma, Kansas, Illinois, New Mexico, Colorado, Michigan, Arkansas, Louisiana, Pennsylvania, New York, and Kentucky are members of an Interstate Oil Compact Commission. This compact of states is authorized by the Congress of the United States. It provides in substance that each state agrees to enact conservation laws; or, if such laws already have been enacted, agrees to continue the same in effect so that the actual enforcement of constructive conservation practices may be realized to the fullest extent in each state. The Compact Commission is composed of the governor, or a duly appointed representative, from each member state.

This body meets at regular intervals for the purpose of thoroughly studying conservation and allocation methods. Through various committees much data are assembled, and studies are made regarding conservation. As a result of these systematic studies, various recommendations are made to the member states for the general betterment of the industry.

Activities of the Compact Commission are purely advisory and, as such, its work is limited to suggestions and influence. Even with this limited scope, it is in a position to accomplish much constructive work in the field of conservation of oil and it proper allocation.

Conclusion

In analyzing present allocation practices in the oil-producing states, the following points should be emphasized:

1. The oil industry is operated primarily on a competitive basis, and for this reason the attainment of maximum efficiency in conservation and allocation is extremely difficult.

2. Systems of control in the various states are geared to meet local operating conditions as well as background and temperament of the people. This is in conformity with American standards of localized government.

3. The actual mechanics of allocation used in the various states differ greatly; and, further, it appears that one basic law or one rigid formula cannot be applied to all the varied conditions.

Vast strides toward general improvement have been made in recent years; however, there is still room for considerable betterment; and the "standards of allocation," as set out in the report of the American Petroleum Institute's special study committee on well spacing and allocation of production, should be of material assistance in further progress. With sincere cooperation between the industry and the regulatory authorities, even more refinements in the systems should be developed at a favorable rate. The work of the Interstate Oil Compact Commission in dissemination and coordination of information also should prove to be of great value in this effort.

•

Foreign Oil Operators Told To Pool Shipping Facilities

American oil companies operating in foreign countries this week took steps to implement provisions of an amendment to Recommendation 38, in which the Office of Petroleum Coordinator calls for pooling of transportation facilities and terminal installations.

The Foreign Operations Committee and 14 companies were instructed to "cooperate with each other" and with other persons and agencies of the United Nations for the purpose of meeting adequately and expeditiously "the petroleum needs of the military forces, the war industries, and essential civilian requirements of the United States and its allies and such other friendly nations outside the continental United States."

The instructions also apply to all other American companies and American citizens engaged in producing, refining, transporting, or marketing petroleum products outside or for consumption outside the continental United States.

Going! Going! Go——!
Get Acme's Mud Collar NOW—To Help Overcome Material Shortages

ACME DRILLING & FISHING TOOLS

Makers of the world famous "Drilmor" Line of Drilling and Fishing Tools for Cable Drillers - the Highest Standard of Quality Since 1900

Acme's Mud-Collar is made of "critical metals." When present limited stock is gone, we can't make delivery promises—as valuable as this rotary tool is in helping lick material shortages.

So don't delay! Order TODAY.

Here's what Acme's Mud Collar can do for you—as proven by satisfied users—in *any formation:*

It lessens drill pipe torque; assures faster, easier cutting, longer runs, fewer "green bits" and makes better hole. . . . Its 6 high-velocity fluid streams keep cutters clean, bit bearings "lubricated" and free of cuttings—while constantly flushing bottom. . . . In sticky formation, it also prevents mud rings and "balled up" bits.

Decrease material purchases by increasing the life of bits and drill pipe. Learn how—with this "wonder tool." Write NOW for full information.

(Also ask for Catalog No. 12. It gives valuable information on correct use and care of Acme cable tools.)

ACME FISHING TOOL CO.
Parkersburg, W. Va. U.S.A.
Export Office — 19 Rector Street, New York, N. Y.

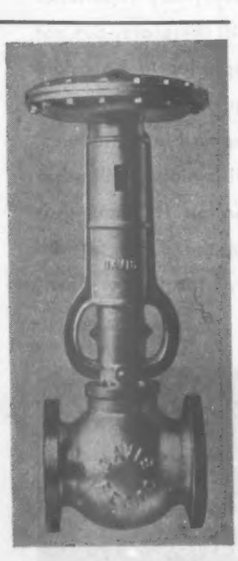
Defense Comes FIRST—with most of Acme's facilities now devoted to war material production. But we'll serve YOU, in a most friendly manner, as best we can.

Flexible Control
with DAVIS DIAPHRAGM MOTOR VALVES

- FOR STEAM, AIR, GAS OR WATER LINES
- DIRECT OR REVERSE ACTING—INTERCHANGEABLE
- CONTROL BY LIQUID-LEVEL, PRESSURE OR TEMPERATURE
- PARABOLIC, SQUARE OR V-PORTED INNER VALVES.

SMOOTH operation, sensitive action and rugged, weather-proof construction will keep Davis Diaphragm Motor Valves on your list of thoroughly dependable control equipment. Standard valves are available in bronze, semi-steel, or steel, with trim of bronze. Special monel or stainless steel. Special alloy steels for body and trim are available on order. If it's a motor valve application, specify DAVIS. Complete details on request.

Write for Latest Catalog



DAVIS REGULATOR COMPANY
2543 SOUTH WASHTENAW AVE., CHICAGO, ILL.

DISTRIBUTOR: Westcott & Greis, Inc., Tulsa, Dallas and Houston.

Prediction of the Shrinkage of Crude Oils*

By D. L. KATZ
University of Michigan, Ann Arbor, Mich.

A. P. I.

Crude oils in a natural reservoir under pressure contain dissolved natural gases which vaporize as the pressure is released on the oil. Vaporization causes a shrinkage in the volume of the remaining oil. This paper presents methods of predicting the shrinkage from measurements made on a well of gas gravity, oil gravity, gas-oil ratio, reservoir temperature, and reservoir pressure. These data, along with the correlations developed from shrinkage measurements on 117 crude oils, permit calculations of shrinkage with an accuracy approaching that of experimental determinations. Approximate methods of predicting shrinkage are presented when limited field data are available. Shrinkage predictions will assist in converting reservoir petroleum reserves into stock-tank quantities.

Paper presented before Division of Production at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

CRUDE oil in a natural reservoir under pressure contains dissolved gases; and, as the crude oil travels from the reservoir to the lease storage tank, the volume of the oil decreases. One barrel of oil in the lease tank may require 1.2 bbl. of reservoir fluid to be produced from the reservoir. The reduction in volume of the reservoir fluid caused by reduction in temperature and by the liberation of the natural gas as the pressure is decreased has been described customarily as the shrinkage of the oil.[1,4] Laboratory measurements are made of this gas-liberation or shrinkage process to give the actual shrinkage values to be used for specific reservoirs. However, in many cases a particular engineer may not have available the shrinkage data for a given reservoir, and it may be necessary for him to estimate this shrinkage. Any computation of oil and gas reserves must include a shrinkage factor to convert reservoir oil to stock-tank oil.

Recent information on the methods of computing the density of liquids containing dissolved gases makes possible more accurate calculation of phase behavior under pressure for crude-oil-natural-gas systems.[2] This report covers several methods for predicting the shrinkage of a reservoir crude oil when such field data as reservoir pressure, reservoir temperature, solubility of the gas in the oil, lease-tank crude-oil gravity, and gravity of the gas (air equals 1) are given for the reservoir under consideration. When all of these items are known, the method is straightforward and reliable; whereas if only solubility, crude-oil gravity, reservoir pressure, and reservoir temperature are known, the method becomes less reliable. For cases in which only crude-oil gravity, reservoir temperature, and reservoir pressure are available, even more approximate methods are presented. A rough method for prediction of the solubility of gas in the crude oil from saturation pressure and crude-oil gravity follows the shrinkage calculations.

The shrinkage calculations do not depend upon the separation process, i.e., flash or differential vaporization of the gas;[1] because the properties of the resulting gas and liquid, as well as the quantity of gas liberated, compensate for any changes in the shrinkage value.

Density of Liquids Saturated With Natural Gas

A method of computing the density of crude oil saturated with natural gas has been presented recently.[3] The method consists of computing the density of the liquid at 60° F. and 1 atm. of pressure by the use of additive volumes and correcting the density from 60° F. and 1 atm.: first, to the pressure desired, and then to the desired temperature. The densities of all constituents heavier than ethane are taken as the normal density in grams per milliliter or pounds per cubic foot of the pure constituent at 60° F. and its vapor pressure. For methane and ethane, it was necessary to devise an apparent density chart which gives the density of methane and of ethane as a function of the concentration (in weight per cent) in the liquid, and of the density of the constituents other than methane or ethane. In most cases the method will compute the density of the crude oil saturated with natural gas to about ±2 per cent.

The calculations of the density of a crude oil saturated with natural gas requires the analysis of the gas which is liberated when the crude oil is reduced in pressure, such as to atmospheric, along with the density of the remaining crude oil at the lower pressure. The quantity of gas liberated is added to the final crude oil, and the total volume of the crude oil saturated with this gas is computed at the saturation temperature and pressure. This volume minus that of the residual crude oil gives the shrinkage caused by vaporization.

Table 1 is an example calculation of the shrinkage for the Crescent crude, and is based upon the data from Lindsly[4] as presented by Standing and Katz.[3] The only unusual feature of the calculation is that the density of the propane and heavier material of the gas plus crude oil must be computed in order to find the density of the ethane to be used from Fig. 1. Likewise, the density of the ethane and heavier material must be computed to find the apparent density of methane for the particular calculation. Fig. 1 gives the apparent densities of methane and ethane as a function of weight per cent in the liquid, and of the density at 60° F. and 1 atm. for the remainder of the material present. Fig. 2 presents the correction to be made for the density at pressure as compared to the density at 1 atm., both at 60° F. Fig. 3 is the chart which corrects the density of the material under pressure from 60° F. to the saturation temperature. The density at 60° F. may not fall on one of the lines given, but may be interpolated between the relatively parallel lines. Both the temperature and pressure-correction charts are similar to those presented with the method of computing the density of crude oil,[2] although the units have been converted from grams per milliliter into pounds per cubic foot because of the convenience in shrinkage calculations.

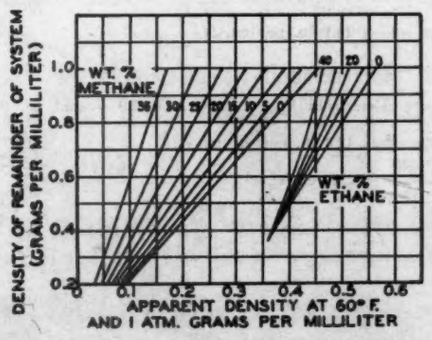

DENSITY OF REMAINDER OF SYSTEM (GRAMS PER MILLILITER)
WT. % METHANE
WT. % ETHANE
APPARENT DENSITY AT 60° F. AND 1 ATM. GRAMS PER MILLILITER

Fig. 1—Apparent density of ethane and methane

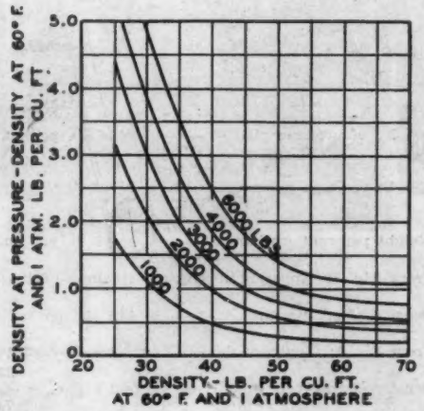

DENSITY AT PRESSURE - DENSITY AT 60° F. AND 1 ATM. LB. PER CU. FT.
8000 LBS.
4000
3000
2000
1000
DENSITY - LB. PER CU. FT. AT 60° F. AND 1 ATMOSPHERE

Fig. 2—Density change of crude oils with pressure

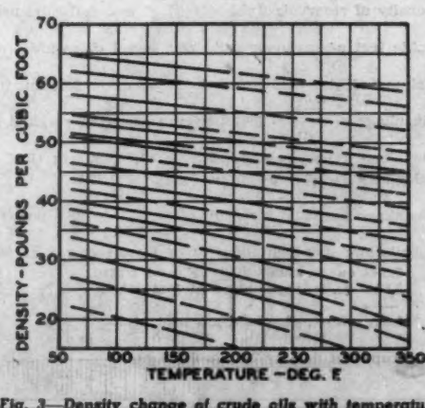


Fig. 3—Density change of crude oils with temperature

*Final report of the special subcommittee on fundamentals of sampling, transporting, and analyzing subsurface samples of crude oil of the topical committee on production technology.

The foregoing procedure for computing the shrinkage of an oil is a convenient one, and is the most reliable method known, if the analysis of the gas vaporized, the resultant gravity of the oil, and the saturation temperature and pressure are available. In most cases, if the analysis of the gas is available, the actual shrinkage measurement may have been made. The need for shrinkage predictions is for cases wherein the analysis of the gas is not known, although the quantity of gas and its gravity or molecular weight may be available.

Apparent Density of Natural Gases

The shrinkage calculation made from the analysis of the gas and the gravity of the resulting crude oil could have been made by using an apparent density for the entire gas mixture which would have been obtained by averaging the density of the constituents in the natural gas. Inasmuch as there is a definite relation between the butane-free gasoline content and the ethane, propane, and butane concentration in natural gases,[3] it would seem that there would be a relationship between the molecular weight or gravity of the gas and this apparent density of the gas when computing the shrinkage of the crude oil saturated with the gas. If this relationship were found, it would be possible to compute the shrinkage from the quantity of gas dissolved in the oil, the gravity of the gas, the gravity of the oil, and the saturation temperature and pressure.

Two types of data were contributed by subcommittee members which would be useful for a correlation of gas gravities and apparent densities. Some were shrinkage experiments which analyzed the gases evolved. Others were simply gas analyses and crude-oil gravities for wells producing saturated crude oils at known gas-oil ratios. The apparent densities of the natural gases, when dissolved in the saturated crude oil for the 22 samples, were computed. The calculation is very similar to that presented in Table 1. The pounds of the gaseous constituents added to the residual crude oil, divided by the cubic feet of the gas when in the liquid state at 60° F. and 1 atm. pressure, is the apparent density of the gas dissolved in the crude oil.

Fig. 4 is a correlation of the apparent densities of the natural gases as a function of the gas gravity and of the crude-oil gravity resulting from the vaporization of a subsurface sample of crude oil. The gas gravity is in reality the molecular weight of the gas divided by 29.0, the molecular weight of air. The differences in the apparent density for the same gas gravity are not represented by the gravity of the crude oil, but it is the best factor which could be found. Table 2 gives the comparison of the apparent density of the 22 natural gases as calculated from the analysis and from the gas gravity of Fig. 4. The percentage error shown on Table 2 should not necessarily be zero as an average, because some correction was made to the curves of Fig. 4 when this figure was used to compute the shrinkage of the large number of crude oils for which gas gravity and shrinkage were given.

It should be noted that the apparent density of

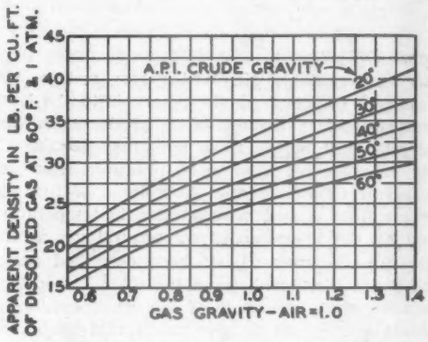


Fig. 4—Apparent density of natural gases

TABLE 1—EXAMPLE CALCULATION OF SHRINKAGE FACTOR FOR CRESENT CRUDE

Given:

Gas liberated (cubic feet per barrel of residual oil)	814
Crude gravity (from Bureau of Mines), °A.P.I.	41.7
Saturation temperature, °F.	149
Saturation pressure, pounds per square inch (absolute)	2,575

GAS ANALYSIS

Component—	Volume per cent
Methane	75.33
Ethane	10.09
Propane	6.96
Butanes	5.58
Pentanes	1.56
Hexanes plus	0.48

CALCULATION OF SHRINKAGE

Component—	Cubic feet	Molecular weight	Pounds	Liquid (pounds per cubic foot, at 60° F. and 14.7 p.s.i.)	Liquid (cu. ft.)
Methane	612	16	25.8	20.1	1.283
Ethane	82.0	30	6.5	30.9	0.210
Propane	56.6	44	6.6	31.8	0.208
Butanes	45.4	58	6.9	36.1	0.191
Pentanes	12.7	72	2.4	39.2	0.061
Hexanes plus	3.9	86	0.8	41.5	0.019
Crude oil	5.61	..	286.0	51.0	5.610
		Total	335.0		7.582
		Propane plus	302.7		6.089
		Ethane plus	309.2		6.329

Density of propane plus $= \frac{302.7}{6.089} = 49.8$ lb. per cu. ft. $= 0.799$ g. per ml.

Weight per cent ethane $= \frac{6.5}{309.2} = 2.1$ lb. per cu. ft.

Weight per cent methane $= \frac{25.8}{335.0} = 7.7$ lb. per cu. ft.

From Fig. 1: Apparent density of ethane = 0.496 g. per ml. = 30.9 lb. per cu. ft.

Density of ethane plus $= \frac{309.2}{6.300} = 49.1$ lb. per cu. ft. $= 0.788$.

From Fig. 1: Apparent density of methane = 0.322 g. per ml. = 20.1 lb. per cu. ft.

Density of reservoir fluid at 60° F. and 1 atm. $= \frac{335.0}{7.582} = 44.2$ lb. per cu. ft.

Density of reservoir fluid at 60° F. and 2,575 lb., using correction from Fig. 2, is 44.2 + 0.9 = 45.1 lb. per cu. ft.

Density of reservoir fluid at 149° F. and 2,575 lb., using Fig. 3, is 42.8 lb. per cu. ft.

Cubic feet of reservoir fluid per barrel of residual oil $= \frac{335}{42.8} = 7.82$ cu. ft.

Volume of dissolved gas = 7.82 − 5.61 = 2.21 cu. ft.

Shrinkage $= \frac{2.21}{5.61} = 39.4$ per cent based on residual oil.

Shrinkage reported by Lindsly = 40.7 per cent (Ref. 4).

Calculated formation-volume factor = 1.394.

Shrinkage based on reservoir oil $= \frac{221}{7.82} = 28.3$ per cent.

Calculation: Apparent density of dissolved gas at 60° F. and 1 atm.

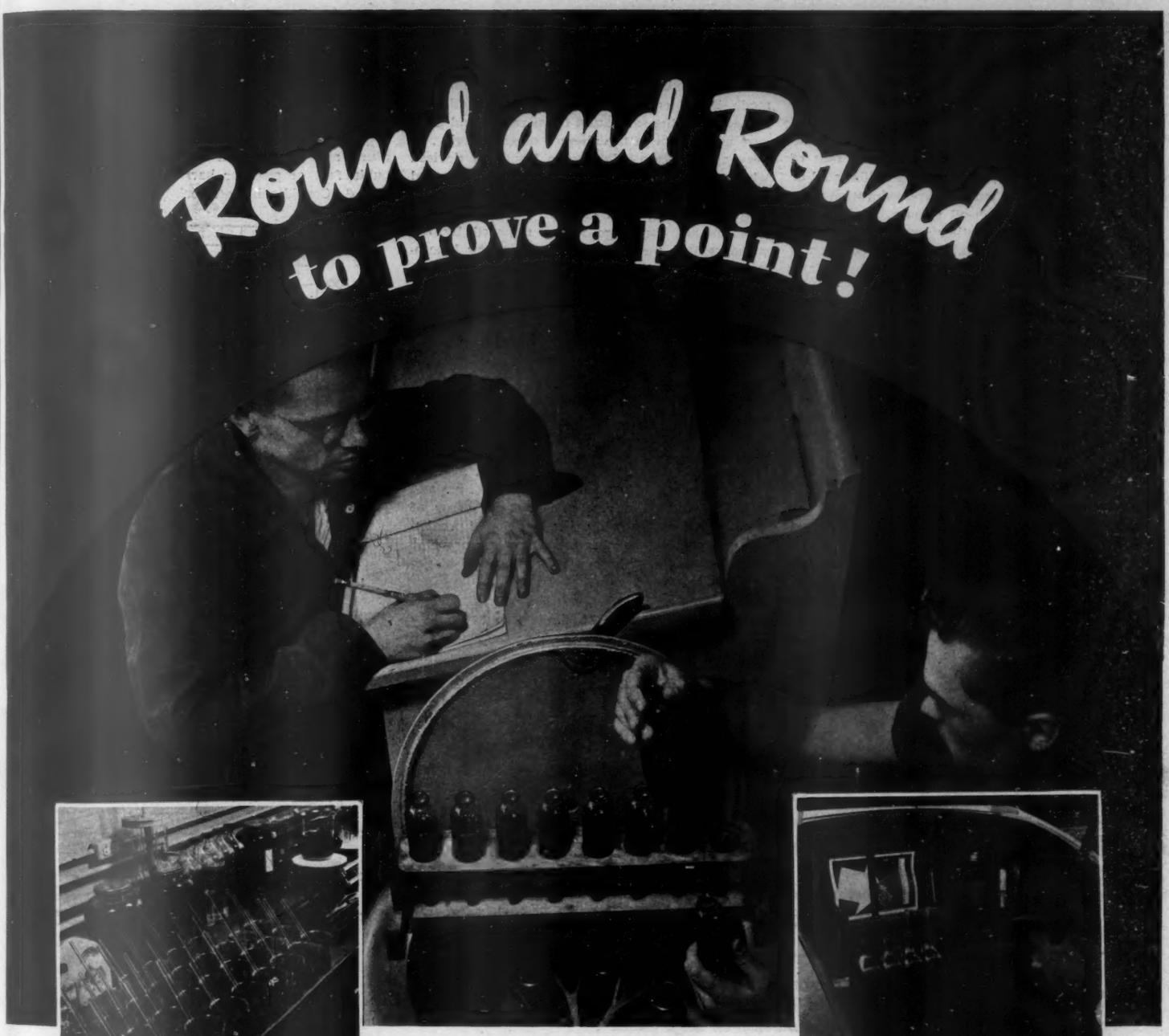
7.583 cu. ft. total at 60° F. and 1 atm.	335.0 lb. total
5.61 cu. ft. residual oil at 1 atm.	286.0 lb. crude oil
1.97 cu. ft. dissolved gas at 1 atm.	49.0 lb. dissolved gas.

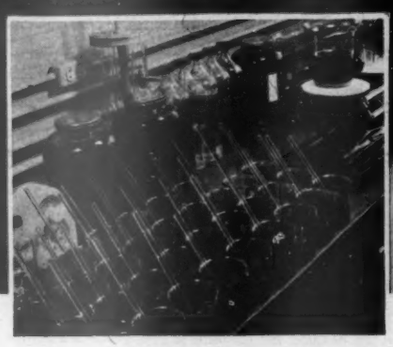
Apparent density of dissolved gas $= \frac{49.0}{1.94} = 24.9$ lb. per cu. ft.

TABLE 2—COMPARISON OF APPARENT DENSITIES OF NATURAL GAS AS CALCULATED FROM ANALYSIS AND FROM FIG. 4

Gas No.	Gas gravity (Air=1)	Crude-oil gravity (°A.P.I.)	Calculated apparent density (lb. per cu. ft.)	Apparent density read from Fig. 4 (lb. per cu. ft.)	Error (%)
1	0.829	30.2	28.4	26.8	−5.6
2	0.653	31.8	23.6	22.3	−5.5
3	0.773	29.9	25.0	25.7	+2.8
4	0.685	36.3	23.5	22.5	−4.2
5	0.695	34.6	24.0	23.0	−4.1
6	0.810	36.3	25.2	25.5	+1.2
7	1.106	39.6	29.2	30.0	+2.7
8	0.767	39.0	23.6	23.9	+1.3
9	0.620	34.8	23.2	21.0	−9.5
10	0.665	36.0	22.6	22.2	−1.8
11	0.660	37.4	21.8	21.7	−0.5
12	0.665	38.4	21.8	21.6	−0.9
13	0.688	38.4	22.6	22.2	−1.8
14	0.705	42.0	22.3	22.0	−1.3
15	0.610	40.8	21.8	19.7	−9.6
16	0.867	41.3	27.0	25.5	−5.6
17	0.865	40.9	25.7	25.5	−0.8
18	0.963	38.7	29.0	28.0	−3.5
19	0.960	41.6	29.4	27.2	−7.5
20	1.040	41.2	28.2	28.5	+1.1
21	0.985	43.2	29.2	27.4	−6.2
22	1.018	42.2	28.2	28.1	−0.4

Round and Round to prove a point!





WHEN your Tret-O-lite representative tests your production in the field and recommends a certain Tret-O-lite compound . . . he doesn't just pull the number out of a hat. He knows that much scientific study has gone into the development and manufacture of that compound. He knows that Tret-O-lite laboratory technicians have tested, checked and rechecked its contents, its stability, its performance. Backed by Tret-O-lite research, he knows he can confidently recommend Tretolite Company products . . . and get better results for you.

Complete Service for Every Field

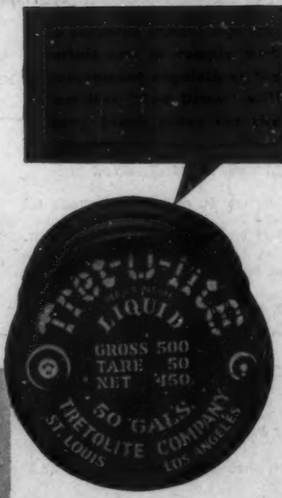
TRETOLITE COMPANY *Manufacturing Chemists*

WEBSTER GROVES, ST. LOUIS COUNTY, MO. • LOS ANGELES, CALIF.

Tret-O-lite

REG. U. S. PAT. OFF.

DEHYDRATING DESALTING



Oil is Ammunition Treat it Right!

a gas is dependent upon the solubility of the gas in addition to the gas and crude-oil gravities. As more data become available, this variable should be included.

Other Shrinkage Calculations

The next simplest method of calculating shrinkage over the use of the gas analysis is that of using the gas gravity, quantity of gas liberated or solubility, saturation temperature, saturation pressure, and residual crude-oil gravity. Members of the subcommittee and other cooperating laboratories submitted the results of 53 experimental shrinkage measurements along with these data. Calculations were made of the percentage shrinkage at the saturation temperature with the liberation of the gas listed and with the resulting crude oil as measured by its A.P.I. gravity. Table 3 is an example calculation of the shrinkage of a saturated crude oil when the gas gravity is given. Table 4 gives the results of the calculations for the 53 cases. Sixteen of the crude oils had an average positive error of 4.5 per cent, whereas 37 of the crudes had an average error of —3.6 per cent, with an algebraic average of —1.2 per cent. These percentages are of the experimental shrinkage value; and, if considered in the light of the error which the calculations would make on an estimation of the quantity of stock-tank oil as compared to the reservoir oil, these errors are reduced materially. For example, the maximum error on crude sample No. 28 is +15.2 per cent, based upon the experimental shrinkage value; whereas this error, if computed upon the basis of the quantity of crude oil in a reservoir as compared to the quantity in the lease storage tank, becomes an error of 2.4 per cent. The general accuracy of this method in the majority of cases approaches that of the experimental measurement. Some of the larger errors may be due to the presence of nonhydrocarbon constituents in the natural gas, such as carbon dioxide or nitrogen. The method is based upon hydrocarbon gases, and may not be expected to be so accurate for nonhydrocarbon gases.

Approximation of Shrinkage

Although the methods described hereinbefore are the more reliable for estimating the shrinkage of crude oils, sufficient data may not be available to use these methods. Approximations of less reliability, but requiring a smaller amount of data, will now be presented.

An approximation of the shrinkage may be made if the crude-oil gravity, the solubility of the gas, and the saturation temperature and pressure are known in the absence of gas gravity. A very approximate relationship has been devised which predicts the gas gravity of the liberated gas as a function of the solubility of the gas and of the crude-oil gravity (Fig. 7). Sixty-four of the experimental shrinkage values reported by the subcommittee members and cooperating laboratories did not include the gas gravity or gas analysis. The gas gravities were predicted from Fig. 7, and then the shrinkage computations were made in the same manner as if the gas gravity had been given as previously described. Table 5 presents the results of such calculations on the 64 crude samples. Thirty-eight of the crude samples have an average positive error of 11 per cent, whereas 26 of the samples have an average negative error of 7 per cent. Calculations for all 117 of the shrinkage values reported, but not using the gas gravity when it was reported, give an average of about 8 per cent for both positive and negative errors, an algebraic average error of +0.64 per cent—showing that Fig. 7, for predicting gas gravity, has been constructed properly even though rather large errors in individual gas gravities do occur.

The simplest relation between shrinkage and other variables is that of shrinkage and solubility of the gas in the oil. Inasmuch as the correction of the residual oil at the vaporization temperature to 60° F. is computed easily, this factor is removed from the experimental shrinkage, and offsets in part the effect of the differences in temperature. The shrinkage values reported by the subcommittee members and cooperating laboratories of 117 crude samples were corrected in Fig. 5 for the saturation or vaporization temperature, and then plotted against the solubility in cubic feet of gas per barrel of residual oil in Fig. 6. Considerable scattering of the points occurs, as would be expected for such a simple relationship, inasmuch as the crude oils came from most of the major oil-producing areas in the United States and had variations in temperature of vaporization, crude-oil gravity, and saturation pressure over a wide range. The relationship has an approximate error on the average of ±15 per cent of the shrinkage, but may be off 25 per cent or more on occasion. The shrinkage obtained in Fig. 6 is enlarged by the temperature correction in Fig. 5 when the shrinkage is computed by this method.

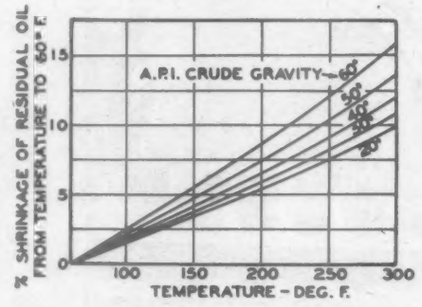


Fig. 5—Correction for temperature of residual oil

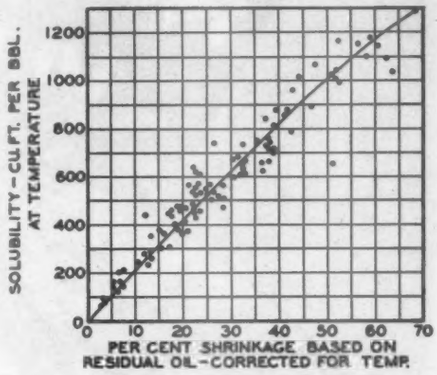


Fig. 6—Shrinkage (corrected for temperature of residual oil) vs. solubility

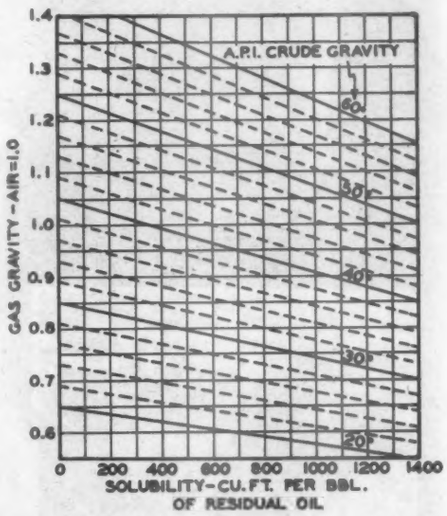


Fig. 7—Prediction of gas gravity from solubility and crude-oil gravity

Prediction of Solubility

As data on the solubility of gases in the crude oil at various saturation temperatures and pressures and for various residual crude-oil gravities were available, a method of prediction of the solubility of gases in crude oil was considered. It is realized that the variation in the source of the sample will have considerable to do with the solubility of the gas for samples of the same crude-oil gravity and saturation pressure and, therefore, any relationship of these variables would be only approximate. Fig. 8 has been prepared, which gives an approximate relationship between the solubility of gas in the crude oil as a function of saturation pressure of the

TABLE 3—EXAMPLE CALCULATION OF SHRINKAGE WHEN GAS GRAVITY, SOLUBILITY, CRUDE GRAVITY, RESERVOIR PRESSURE AND RESERVOIR TEMPERATURES ARE GIVEN

DATA GIVEN FOR CRUDE SAMPLE NO. 2, TABLE 4

Saturation or reservoir temperature, °F.	108	Gas gravity (air = 1.0)	1.031
Saturation or reservoir pressure, p.s.i. (absolute)	1,853	Crude gravity, °A.P.I.	32.8
		Solubility, cubic feet per barrel of residual oil	666

SHRINKAGE CALCULATION

Apparent density of dissolved gas from Fig. 4 = 30.3 lb. per cu. ft.

$$\frac{\text{666 cu. ft. (29.0 molecular weight of air) (1.031 gas gravity)}}{\text{379 cu. ft. per mol}} = \text{52.5 lb. of dissolved gas.}$$

$$\frac{52.5}{30.3} = \text{1.73 cu. ft. of dissolved gas}$$

32.8° A.P.I. = 301.5 lb. per bbl.

5.61 cu. ft. of residual crude oil	301.5 lb. of crude
7.34 cu. ft. at 60° F. and 1 atm.	52.5 lb. of gas
	354.0 lb. total

$$\text{Density at 60° F. and 1 atm.} = \frac{354.0}{7.34} = \text{48.3 lb. per cu. ft. at 60° F. and 1 atm.}$$

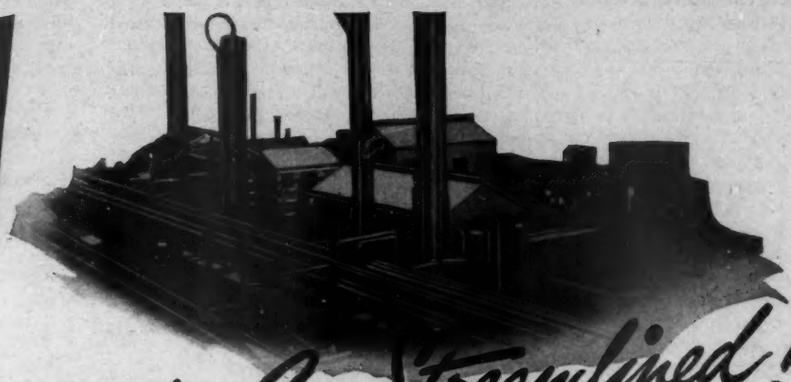
By Fig. 2, 48.3 + 0.6 = 48.9 lb. per cu. ft. at 60° F., 1,853 lb.
By Fig. 3, 48.9 goes to 47.7 lb. per cu. ft. at 108° F., 1,853 lb.

$$\frac{354 \text{ lb.}}{47.7} = \text{7.42 cu. ft. per bbl. of residual oil}$$

5.67 cu. ft. crude oil	
1.81 cu. ft. dissolved gas	

$$\text{Calculated shrinkage} = \frac{1.81}{5.61} = \text{32.3 per cent based on residual oil.}$$

Experimental shrinkage = 34.9 per cent based on residual oil.
Error = —7.4 per cent.
Calculated formation-volume factor = 1.323
Experimental = 1.349
Error = —1.9 per cent



Plants Go Streamlined!

Metric-American orifice meters at a simplified new gasoline plant where equipment and controls are kept at a minimum. The finished liquid product is piped to a refinery at which high-octane aviation motor fuel is made, while the residue gas is sold to a utility which manufactures electric current for war plants.

PLANT SIMPLIFICATION is in order . . . stipulated for new construction or remodeling. This stripping of "non-essentials" applies to equipment as well.

New emphasis therefore is placed on the more practical scientific applications of measurement and control instruments. Their duties are enlarged. Their selection must be scrutinized with greatest care, since replacements to cover "mistakes" may be difficult.

Such new and heavier responsibilities are safely entrusted to Metric-American orifice meters, flowmeters and controls. They have a complete range and adaptability within their fields; a proven efficiency that is a matter of performance record the country over.

These American Meter Company instruments themselves are streamlined for elimination of all superfluous or vulnerable parts. Practical instruments . . . sensitive yet rugged . . . they have fewer working parts; less angular movement and less friction in travel, counterbalances and safeguards to insure closer accuracy. Low-cost accuracy at maintained highest standards!

METRIC METAL WORKS • ERIE, PENNSYLVANIA

AMERICAN METER COMPANY

INCORPORATED (ESTABLISHED 1836)

MEASUREMENT ENGINEERING AND PROCESS CONTROL

For the asking: bulletins that will acquaint you with all Metric-American instruments for flow measurement and control of gases, air, steam, oil and other fluids.

1931

crude oil and the residual crude-oil gravity. A more accurate relationship would require the knowledge of another variable such as gas gravity, but the chances of an engineer's having such additional data without having the solubility are relatively small and, hence such a relationship would have dubious value. The average error of calculating the solubility from Fig. 8 as compared with the experimental solubility is about 25 per cent. Fig. 8 should be used only in cases in which other data are not available. This solubility prediction makes possible another method of predicting shrinkage from crude-oil gravity, saturation pressure, and saturation temperature.

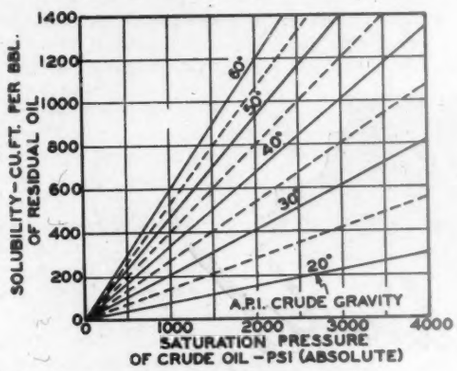


Fig. 8—Prediction of solubility from saturation pressure and residual crude-oil gravity

Summary

Five methods of predicting the shrinkage of reservoir crude oil when the dissolved gas is liberated have been described for cases wherein experimental shrinkages were not available. These methods are of decreasing accuracy for decreasing amounts of information available to predict the shrinkage. The methods are: (1) Computation of the shrinkage when the gas analysis of the liberated gas, quantity of liberated gas or solubility, saturation pressure, saturation temperature, and residual crude-oil gravity are known; (2) calculation of shrinkage when the gravity of the liberated gas, quantity of liberated gas or solubility, residual crude-oil gravity, saturation temperature, and saturation pressure are given; (3) calculation of shrinkage when the quantity of gas liberated or solubility, residual crude-oil gravity, saturation pressure, and saturation temperature are known; (4) calculation of the shrinkage when the solubility of the gas and saturation or vaporization temperature are known; and (5) calculation of shrinkage when only crude-oil gravity, saturation pressure, and saturation temperature are known.

Nomenclature

The term "shrinkage" used in this report generally refers to shrinkage, percentage based on residual or stock-tank oil.[1] Other methods of expressing shrinkage are in use,[6] and the definition of terms should be observed carefully. The formation volume factor is defined[5] as the volume under reservoir conditions of the oil and its dissolved gas from which is derived one volume of crude oil at surface conditions. The shrinkage may be expressed also as a percentage based on the reservoir oil. The difference betwen unity and this percentage based on reservoir oil has been called the "shrinkage factor."[5]

For example, if 1.35 bbl. of reservoir oil containing dissolved gases are required to produce 1.00 bbl. of stock-tank or residual crude oil at 60° F., the following ways may be used to represent this shrinkage:

Shrinkage, percentage based on residual oil = 35 per cent.

Formation volume factor = 1.35.

TABLE 4—COMPARISON OF EXPERIMENTAL AND CALCULATED SHRINKAGE—USING GAS GRAVITY, SOLUBILITY, PRESSURE, TEMPERATURE, AND CRUDE GRAVITY

Crude sample No.	Saturation Temperature (°F.)	Saturation Pressure (p.s.i., abs.)	Crude gravity (°A.P.I.)	Gas gravity (Air=1.0)	Gas solubility (cu. ft. per bbl. of oil)	Shrinkage (Per cent of residual crude) Experimental	Shrinkage (Per cent of residual crude) Calculated from Fig. 4	Error based on experimental (%)
1	209	3,285	41.8	0.925	1,100	70.6	63.0	−10.7
2	108	1,853	32.8	1.031	666	34.9	32.3	−7.4
3	120	735	39.5	0.941	125	9.0	8.9	−1.1
4	196	1,765	30.2	0.861	263	19.2	18.0	−6.2
5	115	1,550	33.9	0.961	359	19.5	19.0	−2.6
6	115	2,000	33.6	0.867	567	28.2	27.2	−3.5
7	212	2,490	31.8	0.869	663	41.9	38.9	−7.2
8	115	3,020	33.4	0.874	737	35.2	34.4	−2.3
9	205	3,650	29.9	0.798	753	41.9	39.5	−5.7
10	211	2,920	36.3	0.82	767	44.7	43.9	−1.8
11	213	3,265	34.6	0.82	820	46.0	46.2	+0.4
12	250	3,155	43.0	0.777	858	50.9	51.2	+0.6
13	211	3,215	36.3	0.817	880	48.6	48.5	−0.2
14	140	1,880	39.6	1.12	995	56.4	56.9	+1.0
15	58	2,900	39.0	0.792	1,020	44.0	42.3	−3.9
16	212	3,555	34.8	0.839	1,031	58.0	55.1	−5.0
17	212	3,570	36.0	0.831	1,048	59.0	56.8	−3.7
18	60	3,400	37.4	0.783	1,172	52.3	46.9	−10.7
19	212	3,950	38.4	0.788	1,180	66.1	61.9	−6.4
20	175	1,547	41.7	0.96	501	34.4	31.0	−9.9
21	171	2,320	55.9	0.82	1,130	67.4	67.2	−0.3
22	130	1,406	41.1	1.08	712	42.0	41.2	−1.9
23	147	1,540	42.6	1.00	575	34.3	33.8	−1.4
24	177	3,020	33.4	0.65	534	27.4	26.9	−1.8
25	95	1,195	37.3	0.97	456	23.8	22.4	−6.0
26	95	1,504	38.0	0.855	685	33.3	32.6	−2.1
27	85	499	32	0.993	214	9.8	10.8	+10.2
28	84	825	35	1.386	390	19	21.9	+15.2
29	85	689	33	0.734	290	15	13.0	−13.4
30	115	883	37.7	1.250	308	19.6	18.7	−4.6
31	115	803	34.6	1.212	263	17.0	15.8	−7.0
32	128	1,842	38.5	1.073	593	33.3	32.8	−1.5
33	128	1,595	38.2	1.101	455	26.1	26.1	0
34	148	513	24.3	0.775	76.6	7	6.9	−1.4
35	180	1,023	25.8	0.828	167.3	12.5	11.8	−5.6
36	151	717	31.8	0.842	142.6	9.9	10.2	+3.0
37	199	2,595	32.5	0.740	488	28.2	27.8	−1.7
38	149	2,212	34.8	0.742	477	23.8	24.0	+0.8
39	198	2,498	35.6	0.806	667	43.0	42.0	−2.3
40	190	2,135	39.0	0.877	628	38.5	41.0	+6.5
41	255	2,345	39.0	0.877	628	44.8	46.2	+3.1
42	149	2,730	48.3	0.783	1,313	74.0	67.8	−8.4
43	180	1,783	63.7	0.830	1,042	72.3	72.6	+0.4
44	168	2,072	26.5	0.947	415	24.5	22.4	−8.6
45	187	3,338	38.5	0.683	566	28.5	30.4	+6.8
46	120	1,314	21.9	0.602	145	7.65	7.2	−5.9
47	177	3,419	37.0	0.799	880	44.9	45.2	+0.6
48	157	2,364	25.9	0.632	353	17.1	17.8	+4.1
49	192	3,519	37.0	0.695	844	43.7	46.8	+7.1
50	205	3,341	37.3	1.043	892	53.0	52.7	−0.6
51	158	2,179	44.7	0.827	738	42.5	41.0	−3.7
52	180	1,899	45.3	0.930	719	45.2	44.0	−2.7
53	133	1,772	21.8	0.575	210	9.9	10.0	+1.0
Column No.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Average+ equals 4.5 per cent; average− equals 3.6 per cent; algebraic average equals −1.16 per cent.

Shrinkage, percentage based on reservoir oil[1]

$$\frac{0.35}{1.35} = 25.9 \text{ per cent}$$

Shrinkage factor[5] $= \frac{1}{1.35} = 0.741$ or $1.00 - 0.259 = 0.741$

The first of these methods was used throughout this report, but the values for the other definitions may be found by the simple calculation shown.

For crude oil containing small quantities of nonhydrocarbon gases, or none at all, the first of these methods has an accuracy approaching that of the experimental determination; whereas the fourth and fifth methods may have errors of 25 per cent or more of the shrinkage value. In addition to the methods of predicting shrinkage, an approximate relationship for predicting the solubility of the gas in the oil from the saturation pressure and the crude-oil gravity of the residual oil has been presented.

Acknowledgment

The accumulation of solubility and shrinkage data and the planning of this problem were done by the subcommittee members and by cooperating laboratories, as follows:

Sumcommittee members: W. B. Berwald, Ohio Co.; J. B. Clark, Stanolind Oil & Gas Co.; P. G. Exline, Gulf Research & Development Co.; J. E. Gosline, Standard Oil Co. of California; H. H. Kaveler, Phillips Petroleum Co.; Carl Vicksburg, Carter Oil Co.; R. J. Schilthuis, Humble Oil & Refining Co.; and D. L. Katz (chairman), University of Michigan. A. G. Loomis, Shell Development Co.; James A. Lewis, Core Laboratories, Inc.; C. V. Millikan, Amerada Petroleum Corp.; and R. E. Heithecker, of the Bureau of Mines, contributed data for the project. The major por-

BETTER be SAFE than SORRY

USE GUIBERSON PACKERS IN ALL WELLS NOW

If your well surface connections should be destroyed by enemy action or other causes — a GUIBERSON Packer installed in the well will —

1. Shut off the annular space between tubing and casing and prevent the well from flowing wild through the casing. (To render control of the well complete, in event of such emergency, flow can be prevented through tubing also, by installing automatic shut-off device in bottom of tubing.)
2. Prevent well from catching on fire.
3. Prevent tubing from dropping and being damaged.

The famous GUIBERSON H3R, C-1, and KV30 Packers not only will protect your wells in the ways described, but these packers will be found the most efficient and dependable yet developed for every application for which packers are required.

TYPE H3R PACKER

The GUIBERSON Type "H3R" is the ideal production packer. Ease in setting and pulling from well, full recovery of rubbers without damage, fluid by-pass when pulling, dovetailed slips and seamless steel mandrel of upset diameter, enable this packer to handle toughest well applications.

Packing rubber design is radically different. Consists of three packing rings of oil resisting compound, the end rings having molded-in steel bushings and hairpin reinforcing wires. Excellent for wells of any depth or in wells where differential pressures reach 6,000 lbs. per sq. in.

TYPE C-1 PACKER

GUIBERSON "Control Head" Packers are the most efficient all-purpose packers yet developed. Type "C-1" has 3" vertical valve opening and is a single-rubber packer. Packing medium is a long-lived, highly oil-resisting compound which will not disintegrate or stick to pipe.

Control-head feature is most valuable for running in flowing wells, in wells having heavy fluid, for testing purposes when tubing is plugged, and for acidizing purposes. Valve can be opened, or packer reset higher or lower at any time, by simple manipulation of tubing from surface.

TYPE KV30 PACKER

The GUIBERSON Type KV30 Packer is a tremendously tough and sturdy super-packer of our control-head type, developed to overcome a number of familiar packer troubles. Among its outstanding feaures are (1) its dual-type control-head valve, offering both a metal-to-metal ground seat and a composition valve sleeve, either of which would give a leak-proof seal; (2) its internally reinforced packing sleeve, assuring complete recovery even after being subjected to pressures of 6,000 lbs. per sq. in.; (3) its extra-sturdy anchoring device, with two massive 1¼" gudgeons.

Type KV30, here shown, has 30" valve lift. Type KV8 has 8" valve lift. Type K has no control valve.

For Further Information see GUIBERSON Section, 1942 Composite Catalog

THE GUIBERSON CORPORATION, DALLAS, TEXAS

Representatives in All Important Oil Fields in the United States

California Distributor:
W. R. Guiberson Co., Los Angeles, Calif.

BETTER BE SAFE THAN SORRY GUIBERSON

Export Representative:
I. Frank Brown, 30 Rockefeller Plaza, N. Y.

WEDGE GATE VALVES
LAST LONGER

When Hard Faced with
COLMONOY

COLMONOY alloys offer extreme resistance to galling, corrosion, "wire drawing," and abrasive grit. This unretouched photograph shows a ⅛" cast seat ring of COLMONOY, furnace welded to a wedge gate. COLMONOY greatly increases the life of wedge valves, in spite of high temperatures, extreme pressures and other severe operating conditions.

The exceptionally high wear resistance of the hard surface of COLMONOY alloys will protect all vital wearing parts of your equipment. Mild steel parts coated with COLMONOY alloys wear from 3 to 10 times as long as new parts made of high alloy steel.

WRITE TODAY

Learn about COLMONOY and what it is doing to *conserve vital metals.*

WALL-COLMONOY CORP.
720 FISHER BUILDING, DETROIT, MICHIGAN
Branch Offices: NEW YORK CITY; BLASDELL, N. Y.; CHICAGO; TULSA; WHITTIER, CALIF.
Other Branches in Canada.

COLMONOY
Hard Surfacing Alloys and Overlay Metals

It's No Joke!
THIS WAR OF OURS

Likewise the purchasing of hoisting equipment to help keep your war materials moving is a serious matter. Specify the hoist with the safety valve handle: the hoist that will operate in any position, horizontally or vertically, or either end up — the Coffing "Safety-Pull" Ratchet lever hoist—and you will have the most useful lifting or pulling tool available.

See Your Distributor or Write for Catalog No. FG-6.

COFFING HOIST COMPANY
Ratchet Lever, Spur Geared and Electric Hoists
800 WALTER ST., DANVILLE, ILLINOIS

tion of the calculations was made by John W. Delaplaine as an NYA assistant, and as graduate research work at the University of Michigan. The problem originally was suggested by H. H. Power of the University of Texas, who was chairman of the topical committee on production technology at the time.

References

1. D. L. Katz, "Progress Report of Subcommittee on the Fundamentals of Obtaining, Transporting, and Analyzing Subsurface Samples of Crude Oil," Proc. A.P.I. 21M (4) 135 (Production Bull. 225) (1940).
2. M. B. Standing and D. L. Katz, "Density of Crude Oils Saturated With Natural Gas," Trans. Am. Inst. Mining Met. Engrs. 146, 159 (1942).
3. G. G. Brown and D. L. Katz, "Polymerization and What It Means to the Natural-Gasoline Industry," Proc. Natural Gasoline Assoc. America, 42 (1937).
4. B. E. Lindsly, "A Bureau of Mines Study of a 'Bottom-Hole' Sample From the Crescent Pool, Oklahoma," Pet. Engr. 7, 34 (1936).
5. Norris Johnston, "Glossary of Terms Relating to Reservoir Behavior," Proc. A.P.I. 22 (4) 86 (Production Bull. 228) (1941).

TABLE 5—COMPARISON OF EXPERIMENTAL CALCULATED SHRINKAGE—USING CRUDE GRAVITY, SOLUBILITY, PRESSURE, AND TEMPERATURE (GAS GRAVITY NOT GIVEN)

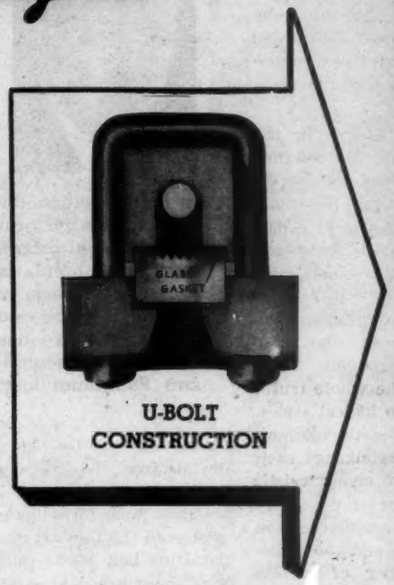
Crude sample No.	Saturation Temperature (°F.)	Saturation Pressure (p.s.i. abs.)	Crude gravity (°A.P.I.)	Gas solubility (cu. ft. per bbl. of oil)	Shrinkage (Per cent residual crude) Experimental	Shrinkage (Per cent residual crude) Calculated from Figs. 7 and 4	Error based on experimental (%)
1	139	2,278	40.1	1,103	62.0	55.6	−10.3
2	130	1,460	40.8	789	46.3	42.0	−9.3
3	149	1,373	42.4	539	29.7	31.8	+7.1
4	144	1,550	42.4	677	39.5	39.2	−0.7
5	150	2,920	41.5	1,066	52.2	55.3	+5.9
6	122	1,120	41.0	475	25.2	26.9	+6.7
7	106	161	40.0	21	2.2	3.2	+45.5
8	98	1,092	40.4	458	25.6	24.0	−6.2
9	98	660	39.5	284	15.9	16.3	+2.5
10	75	146	36.2	9.3	0.83	1.0	+20.5
11	117	1,167	44.9	502	28.5	29.4	+3.2
12	97.5	1,252	33.0	522	24.0	23.9	−0.4
13	90	1,438	33.2	454	18.9	20.8	+10.0
14	90	1,281	35.5	436	19.1	20.2	+5.8
15	87	1,339	41.8	677	31.8	33.8	+6.3
16	180	3,380	36.8	614	28.8	33.9	+17.7
17	118	1,050	42.5	355	18.4	21.0	+14.1
18	125	1,160	42.2	428	25.9	24.9	−3.9
19	166	1,440	43.7	665	56.6	41.0	−27.5
20	132	1,095	41.1	470	32.9	27.6	−16.1
21	124	1,270	42.3	518	30.7	29.2	−4.9
22	110	1,135	38.7	283	14.6	16.0	+10.0
23	118	960	41.2	235	15.6	14.6	−6.4
24	100	1,385	35.4	276	13.7	13.8	+0.7
25	94	695	37.7	144	9.3	8.6	−7.5
26	135	1,225	39.7	385	22.1	22.2	+0.4
27	128	1,160	42.2	450	25.8	26.8	+3.9
28	194	2,120	49.4	705	46.2	48.2	+4.3
29	199	2,785	33.0	612	38.4	34.1	−11.2
30	207	4,100	49.6	1,155	63.4	61.8	−2.9
31	172	2,535	40.0	656	37.8	37.8	+0.0
32	170	2,125	35.0	470	25.6	26.5	+3.5
33	147	1,690	42.0	618	37.0	35.7	−3.5
34	110	1,565	41.0	570	25.7	31.8	+23.7
35	170	1,665	43.0	554	33.7	34.9	+3.6
36	130	1,477	40.8	763	29.7	40.7	+39.4
37	128	1,990	41.3	640	25.7	35.5	+38.2
38	79	546	39.3	164	8.0	8.9	+11.2
39	114	2,034	37.7	543	24.8	27.7	+11.7
40	207	3,340	38.3	960	49.8	56.8	+14.1
41	144	518	21.9	71	6.4	5.9	−7.8
42	198	2,197	38.3	549	31.4	33.6	+7.0
43	170	2,264	31.3	442	17.0	21.1	+24.1
44	168	2,560	29.8	459	22.2	21.2	−4.5
45	157	1,194	26.6	503	19.7	16.0	−18.8
46	174	2,313	38.8	529	29.0	30.8	+6.2
47	97	1,371	35.0	468	21.2	22.0	+3.8
48	118	1,104	41.5	364	22.8	21.1	−7.0
49	156	2,107	46.9	1,027	56.8	58.0	+3.5
50	156	1,776	26.6	247	14.6	13.8	−5.5
51	158	2,789	31.2	451	22.0	24.0	+9.1
52	127	788	22.4	98	5.9	6.3	+6.8
53	185	2,264	36.7	526	27.8	30.8	+10.8
54	142	682	38.4	371	24.9	22.2	−10.8
55	90	1,312	34.0	399	19.6	18.8	−4.1
56	126	1,230	23.2	161	8.3	8.1	−2.4
57	180	2,756	41.1	1,010	57.7	56.2	−2.7
58	161	2,202	37.8	538	31.0	30.2	−2.6
59	94	264	34.4	150	8.9	8.1	−10.1
60	135	1,830	42.5	745	42.0	41.0	−2.4
61	89	1,175	36.4	366	17.3	17.8	+2.9
62	91	1,326	33.4	380	16.5	17.4	+5.4
63	84	1,323	36.0	475	20.0	21.1	+5.5
64	112	1,684	33.0	621	25.1	29.1	+16.0
Column No.	(1)	(2)	(3)	(4)	(5)	(7)	(8)	(9)

Average+ equals 11.1 per cent; average− equals 7.3 per cent; algebraic average equals +3.6 per cent.

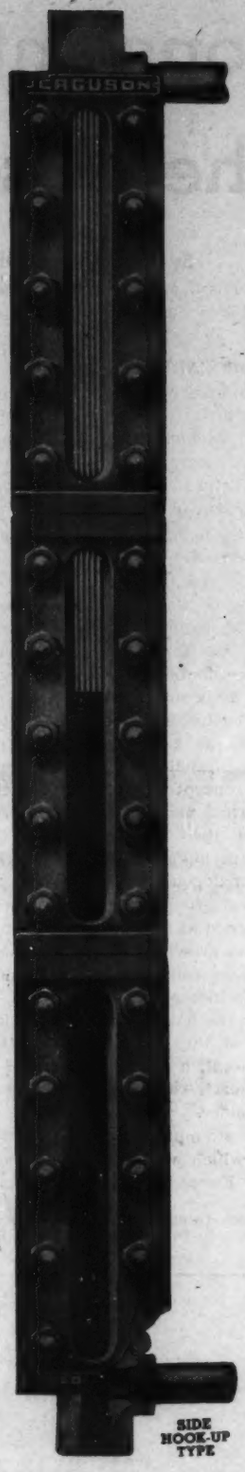
JERGUSON

Reflex Gages

..there's no mistaking that Black and White separation



U-BOLT CONSTRUCTION



SIDE HOOK-UP TYPE

Standard JERGUSON Transparent Gages—for use where the color or condition of the liquid must be observed — are designed for pressures up to 2,000 pounds and temperatures up to 1,000° F.

WHITE means space . . . black means liquid! At a glance you know the level of the liquid in the column. The JERGUSON Reflex Gage provides the sure way to disclose this important operating condition.

But the gage should provide more than maximum visibility. It should be strong enough and protected enough to stand up under high pressures, high temperatures and corrosion.

Durability and JERGUSON Gages are synonymous terms.

» » » »

Standard JERGUSON Reflex Gages are designed for temperatures ranging up to 1000° F. and for pressures up to 3,200 pounds.

Special Gages of both types designed for higher specifications.

JERGUSON GAGE & VALVE CO.

85 FELLSWAY **SOMERVILLE, MASS.**

REPRESENTATIVES:

Desco Corporation
2nd & Welsh Sts., Chester, Pa.

Associated Valve & Engineering Co., 510 North Dearborn St., Chicago, Ill.

W. D. Emery Co.,
1015 McBirney Building,
Tulsa, Okla.

O'Brien Equipment Co.
2726 Locust Boulevard,
St. Louis, Mo.

Bushnell Controls & Equipment Co., (All of California)
117 West Ninth St.,
Los Angeles, Calif.

H. R. Bowers
1758 Wright Ave., Cleveland, Ohio
Rocky River Branch

J. Arthur Moore, 342 Madison Ave.,
New York, N. Y.

The J. A. Rossiter Co.
Houston, Texas

Murray-Baker-Frederic, Inc.,
628-630 S. Peters St.,
New Orleans, La.

Paul B. Huyette Co., Inc.,
401 North Broad St.,
Philadelphia, Pa.

11-JV-2

Constants of Some Hydrocarbons in The Gasoline Boiling Range

By CECIL E. BOORD*
Supervisor, A.P.I. Hydrocarbon-Research Project,
Ohio State University, Columbus, Ohio

A P. I.

The paraffin hydrocarbons are best regarded as a collection of many subseries, each containing a characteristic structural group. These subseries become more numerous and more complex as the number of carbon atoms is increased. The normal paraffins form the most complete and the simplest structural type. As the possible structures for the paraffins are developed, other uniform structural types will emerge, i.e.: n-C_nH_{2n+2} (*n*-paraffins) and n-C_nMe_{n+2} (*n*-methylparaffins).

There is some evidence that melting point is a function of the purity of the structural type. Carbon atoms 2 and 3 in a paraffin chain are key positions from the standpoint of physical-constant modification. Additional methyl groups substituted in the 2-position augment the effect of the methyl group at the end of the chain. Additional methyl groups substituted in the 3-position tend to counterbalance the effect of the methyl group at the end of the chain.

Double bonds when introduced into a hydrocarbon structure act in a similar manner. Their effects may be additive or counterbalanced. The effect of point of unsaturation may be counterpoised or added to that of a methyl group. Numerous graphs and tables are used to illustrate these points.

Paper presented before Division of Refining at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

HYDROCARBONS are divided into two great groups, cyclic and noncyclic in structure. The paraffins form the basis of the noncyclic group, inasmuch as the monoolefins, diolefins, and acetylenes may be regarded as derivatives of the parent saturated hydrocarbons having the same arrangement of carbon atoms.

In like manner the cycloparaffins form the structural basis of the cyclic group. Cycloolefins, diolefins, and triolefins may be regarded as derivatives of the cycloparaffin having the same carbon skeleton. The aromatic series form a particular case among the cyclotriolefins in which the three double bonds are spaced symmetrically around a six-atom carbon ring.

It is customary to think, and to speak, of the paraffins as a single series. Those who have worked intimately with these compounds know such a concept does not express the whole truth. The normal paraffins form a more logical series, whereas the 2-methylalkanes, 3-methylalkanes, 2,2-dimethylalkanes, and 3,3-dimethylalkanes each form analogous series having a characteristic structural group. The paraffins, therefore, are to be regarded as a collection of many subseries, the collection growing more numerous and the structure more complex as the number of carbon atoms is increased.

When the boiling points, densities, or refractive indices of the paraffins are plotted against carbon content, a compact family of curves may be drawn, each representing a characteristic structural isomer.

Many attempts have been made to evolve formulas which will reproduce and extend these curves.[1] Formulas of this type may be quite accurate and can be very useful, but are likely to deviate from the observed values for those curves which lead far down into the low molecular weights. Such formulas are empirical, and do not give even the faintest clue as to why all branched paraffins boil lower than the normal isomer, or why those isomeric paraffins with methyl groups in the 2 and/or 2' position are less dense and less refractive than the normal isomer whereas those isomers bearing methyl groups in the 3 and/or higher positions are more dense and more refractive.

It has long been known that the melting points of the normal paraffins do not fall on a smooth curve.[2] When the melting points are connected in numerical sequence, an alternately large and small rise in the melting point becomes obvious Two smooth curves can be drawn, one connecting those members of the series containing an even number of carbon atoms, and the other connecting those with an odd number of carbon atoms.

A similar alternation has been observed for the melting points of the *a,a'*-dicarboxylic acids.

The alternation in the melting points is attrib-

*Author's title: "The Physical Constants of Some Hydrocarbons in the Gasoline Boiling Range."

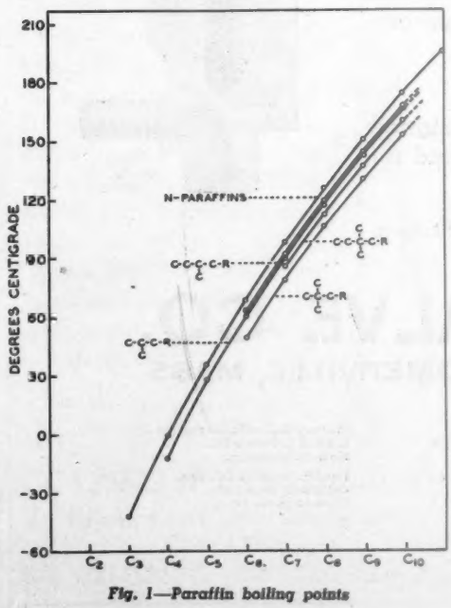


Fig. 1—Paraffin boiling points

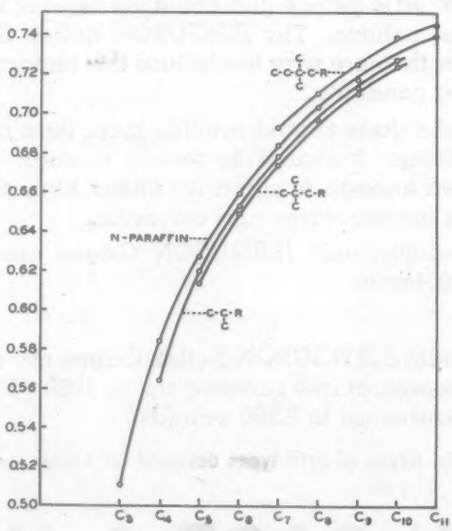


Fig. 2—Paraffin densities, d^{20}_4

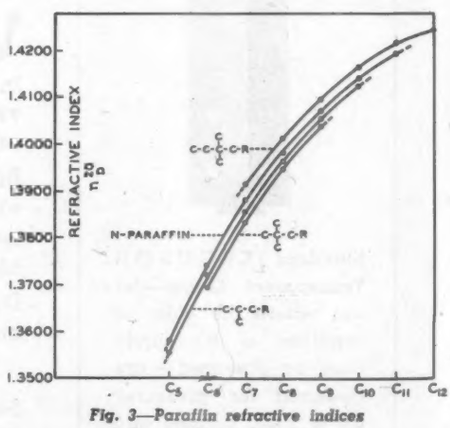


Fig. 3—Paraffin refractive indices

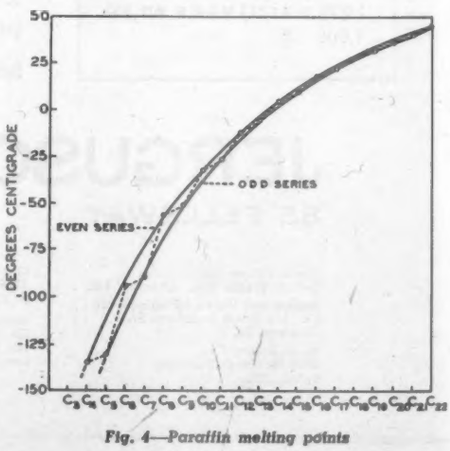


Fig. 4—Paraffin melting points

A GOOD MAN

Business is complicated these days, emphasizing the importance of close relationship between the petroleum industry and supply organizations.

As a Frick-Reid customer you enjoy a supply service so basic as to have become an integral part of the life and work of the petroleum industry. Frick-Reid Stores are as typical of the oil country as the derricks, the pumping units, the tanks, the pipe lines and the great refineries.

And, being so much and for so long a vital part of the petroleum industry, Frick-Reid requirements command respect and precedence wherever good supplies and equipment are made.

Your Frick-Reid store manager is a good man. Through him your buying power is greater than you know. It has no limitations aside from those now universally imposed.

FRICK-REID *Supply Corporation*

TULSA, OKLAHOMA

uted commonly to the polarity of the terminal groups at the ends of the chain. When the number of carbon atoms is odd, these terminal groups reinforce each other; and when the number is even, their effects are opposed.

The boiling points of the *n*-paraffins, as we have seen, do fall on a smooth curve. The alternation has disappeared, but the effect may be made apparent if one considers the rise in boiling point produced by replacing each hydrogen atom of a parent paraffin in turn by a methyl group. Let us consider, for example, *n*-heptane. If we substitute a methyl group for hydrogen successively upon carbon atoms 1, 2, 3, and 4, the 4 isomers *n*-octane, 2-methylheptane, 3-methylheptane, and 4-methylheptane will be produced. The boiling-point increases produced by these substitutions form an alternating series. In Fig. 5 the above procedure has been applied to each of the nine isomeric heptanes in turn. In general, the alternation is apparent in each case. The substitution of methyl groups on carbon atom 2 greatly enhances the effect and results in an abnormally low rise in the boiling point.

The introduction of a methyl group upon carbon atom 3 counterbalances the effect of the methyl group in position 1. The increase in the boiling point from *n*-heptane to *n*-octane is 27.2° C., but when one considers all the substitutions by which a heptane can be converted to an octane, the boiling-point rise may be as low as 17.7° C. or as great as 35.8° C.

The result of this alternating effect of the methyl group is to cause an overlapping and confusion in the initial stages of the boiling-point curves. In Fig. 6 the heptane-octane segment of the boiling-point curves has been magnified, and the actual differences accentuated by moving the octane scale back 25° C.

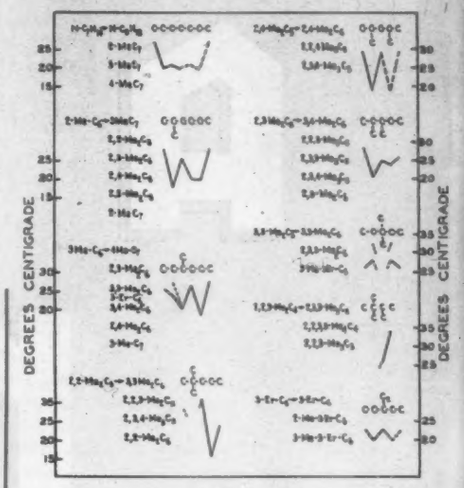


Fig. 5—Heptane-octane boiling-point rise

It is immediately apparent the curves for the 2-methyl-, 3-methyl-, 2,2-dimethyl-, 2,4-dimethyl- and the 2,2,4-trimethyl derivatives are quite similar to the curves of the normal hydrocarbons. Actually, the slope is a little greater in each case. Contrasting sharply with these, the curves for

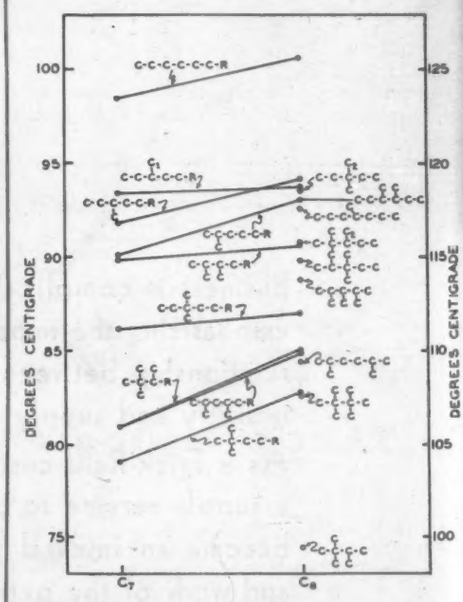
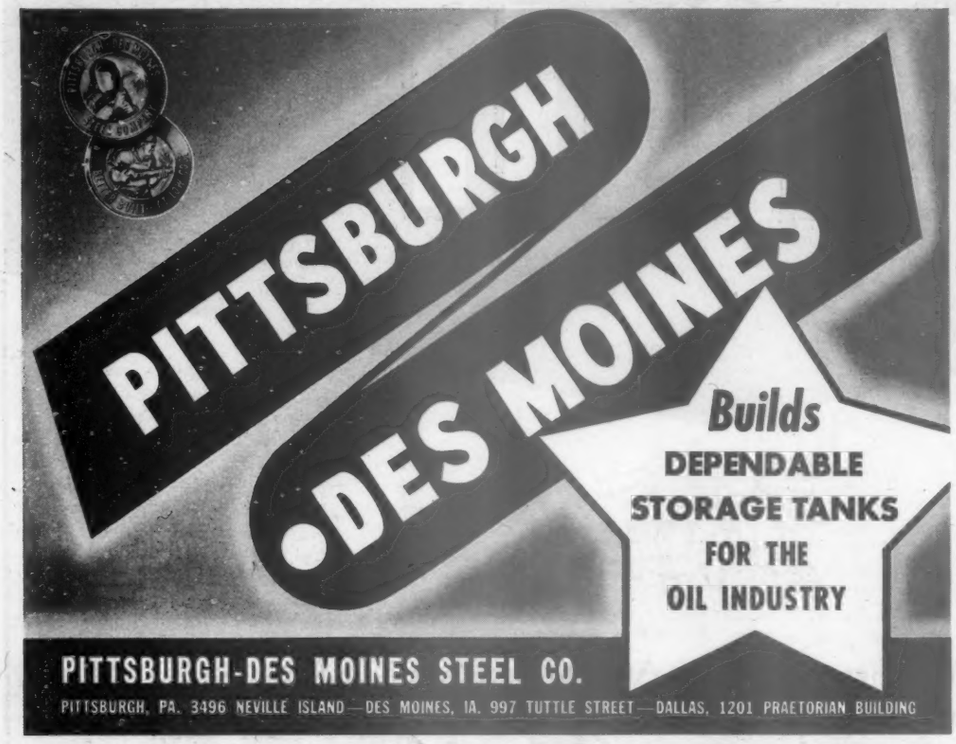


Fig. 6—Heptane-octane boiling points

the 2,3-dimethyl, 3,3-dimethyl-, and 3-ethyl- derivatives form a group very similar in character but having a slope less than that of the normal hydrocarbon.

These variations in the physical constants, caused by moving a methyl group from position to position on a parent hydrocarbon, remind us our concept of the paraffin series is always derived from a single point of view. Invariably we think of paraffins only as hydrocarbons. Each isomer is derived by substituting methyl groups for the hydrogen on the normal paraffin corresponding to the longest chain. Seldom do we carry the development of this concept to its logical conclusion, when all of the hydrogen atoms of the parent have been replaced by methyl groups. The normal paraffins form a series, each member of which is composed of a continuous chain of carbon atoms fully saturated by hydrogen atoms as illustrated by "A." An equally logical series may



I'LL TAKE THE WHITE ONE EVERY TIME!
INCH
2
TRADE
3
STEVENS WYTEFACE A
KEUFFEL & ESSER CO.
WYTEFACE "A"
TRADE MARK
STEEL TAPES
Easy-to-read, raised black graduations on crack-proof white surface . . . resist abrasion from oil, sand, scraping on the pipe pile, etc. In all sizes and types—in cases or reels. Ask your dealer—or write for catalog.
K&E
REG. U. S. PAT. OFF.
EST. 1867
KEUFFEL & ESSER CO.
NEW YORK—HOBOKEN, N. J.
CHICAGO · ST. LOUIS · SAN FRANCISCO · LOS ANGELES
DETROIT · MONTREAL

FIGHTING POWER

That's Saving *Man Hours . . . Money . . . Materials!*

Just look at the latest figures on U. S. production of war materials and equipment. Aren't they encouraging?

It's just further proof that when American ingenuity, energy and determination go to work, there's nothing can stop her short of Victory.

The great fleets of ships, planes, tanks that are being produced every month require more and more petroleum products. This means that electrically operated pumps, pipe lines, refineries and drilling units must stay on the job, and be ready to perform even greater tasks than they have been accustomed to heretofore.

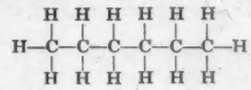
Well, electrically powered equipment can and WILL do it. Give it a regular check-up and make necessary adjustments and repairs promptly. Proper maintenance will keep your motors in perfect operating condition—indefinitely.

Get in touch with your Utility Electric Power service company concerning any question regarding repairs and maintenance. They will be glad to offer friendly counsel and suggestions.

Use Utility Electric Power!

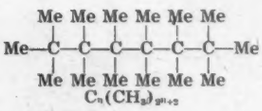
PETROLEUM ELECTRIC POWER ASSOCIATION

be conceived, each member of which is composed of a continuous chain of carbon atoms fully saturated with methyl groups as illustrated by "B."



C_nH_{2n+2}

"A"



$C_n(CH_3)_{2n+2}$

"B"

The methylcarbon series, beginning with neopentane and continuing through hexamethylethane and to higher members, as indicated by "B," forms an equally logical and equally systematic series as the normal paraffins. Between these two systematic structural series types lie most of the isomeric paraffins with which we are familiar.

When we took up the purification of the 18 isomeric octanes in our laboratory, we found *n*-octane and the three methylheptanes to crystallize readily and to give sharp melting points. At the other extreme, tetramethylbutane and the four trimethylpentanes also crystallized with greater or less ease. Thus far ethylhexane and the six dimethylhexanes have resisted all efforts to obtain them consistently in the crystalline condition. One may well ask why do these mixed structural types tend to resist crystallization.

Or again, it is interesting to recall that our reforming processes, when applied to a normal paraffin, cause it to undergo isomerization to a more highly branched isomer but the isomerization does not continue to complete methylation. On the other hand, one may start with a highly methylated product and by the same reforming process lengthen the chain approaching the intermediate isomer for the opposite side. It would be interesting to know the motivating forces which cause these systematic structural types to become merged in an intermediate hybrid structure.

When a point of unsaturation is introduced into a paraffin producing an olefin or an acetylene, quite analogous effects are produced. Each isomeric paraffin becomes the parent of a group of isomers. The resuling change in the value of the physical constant is a function not only of the structure of the original paraffin, but also of the position in which the double bond is introduced. Table 1 shows the melting points, boiling points, densities, and refractive indices of the *n*-octenes and *n*-octynes.

TABLE 1—N-OCTENES AND N-OCTYNES

Hydrocarbon	Melting point (°C.)	Boiling point (°C.)	d_4^{20}	n_D^{20}
1-Octene	—102.1	121.6	0.7150	1.4090
2-Octene	—94.0	125.2	0.7192	1.4130
3-Octene	—110.0	123.2	0.7146	1.4128
4-Octene	—93.8	122.3	0.7136	1.4119
1-Octyne	—79.5	126.2	0.7457	1.4159
2-Octyne	—62.0	137.1	0.7591	1.4269
3-Octyne	—105.0	132.9	0.7529	1.4250
4-Octyne	—102.9	131.5	0.7506	1.4247

It will be observed that the melting points are alternately lower and higher as the point of unsaturation passes from position 1 to 2 to 3 to 4. The boiling points, densities, and refractive in-

TABLE 2—HEXENES AND HEXANES

Hexene structure	Olefin type	Boiling point of hexane (°C.)	Boiling point of hexane (°C.)	Deviation for olefin (°C.)
C–C=C–C C C	5	73	58.1	+14.9
C–C=C–C–C C	4	69.9-70.2 65.1-65.7	63.2	+6.9 +2.2
C–C=C–C–C C	4	67.2-67.5	60.2	+7.2
C=C–C–C C C	3	66.2-66.7	63.2	+3.3
C=C–C–C–C C	3	61.5-62.0	60.2	+1.6
C=C–C–C C C	3	56.0-56.5	58.1	—1.8
C–C=C–C–C–C	2	67.0-68.1	68.1	—0.7
C–C–C=C–C–C	2	66.6-66.9	68.7	—1.9
C–C=C–C–C C	2	57.7-57.8 54.2-55.2	60.2	—2.4 —5.5
C=C–C–C–C–C	1	63.4-63.7	68.1	—5.1
C=C–C–C–C C	1	53.6-53.9	60.2	—6.4
C C=C–C C C C	1	53.6-54.0	63.2	—9.4
C=C–C–C C	1	41.2	49.7	—8.5

It's that ONE-MAN GANG again

-getting another job done!

You see 'em everywhere in the oil fields — these little P&H's! They're the one-man gangs that handle all kinds of jobs . . . digging slush pits and basements — trenching and laying pipe — erecting structural steels — handling all kinds of materials. There is practically no end to the work they'll do. And quickly!

Travel is made sure and easy with true tractor type crawlers and three speed transmission. That's for fast foot-work on the close-in jobs. On the long hauls, they ride their own trailers at regular traffic speeds.

Strength? They're built throughout of rolled alloy steels, all welded. It's the toughest excavator construction known.

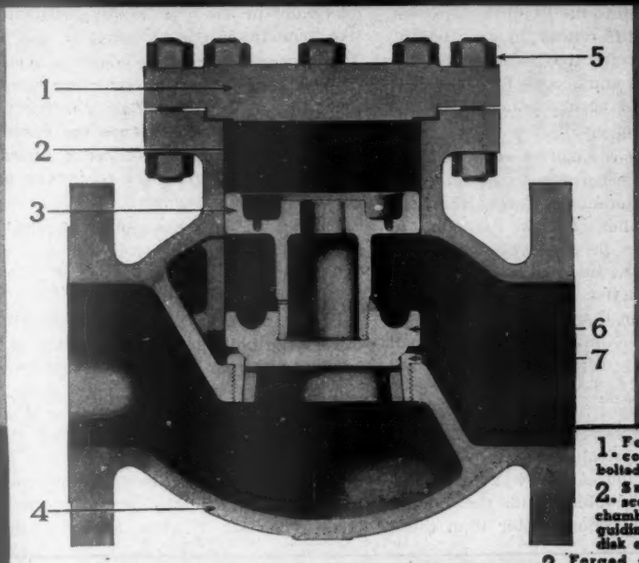
These are just a few of the reasons why they're favorites in the oil fields. It's easy to get *all* the reasons. Write for literature.

General Offices: 4527 W. National Ave., Milwaukee, Wisconsin

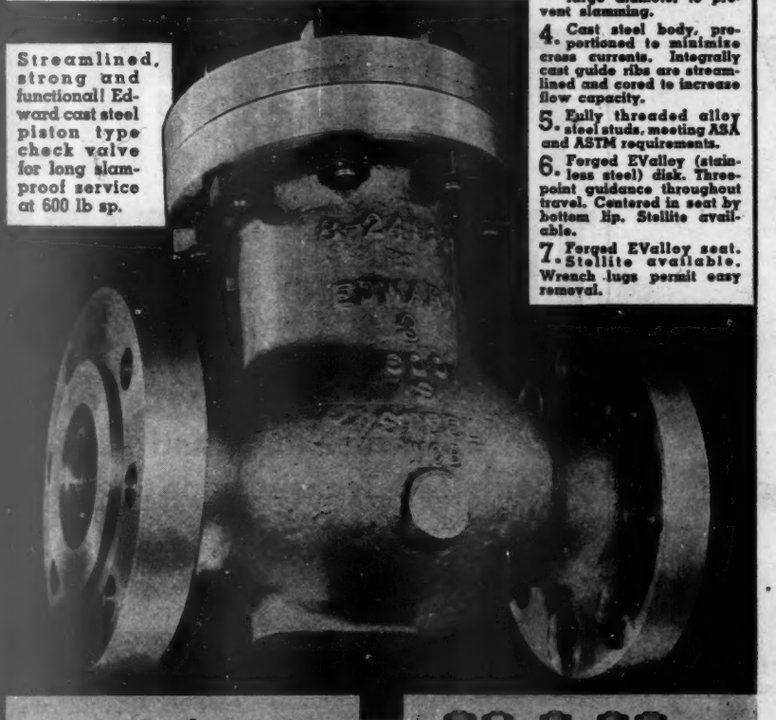
OTHER SIZES UP TO 5 CU. YD. CAPACITY: GASOLINE, DIESEL OR ELECTRIC POWER.

HARNISCHFEGER
CORPORATION
EXCAVATORS • ELECTRIC CRANES • ARC WELDERS P&H HOISTS • WELDING ELECTRODES • MOTORS

CUT SHOCK, SLAM and CLATTER with EDWARD *Piston Type* Check Valves



1. Forged steel cover, through bolted to body.
2. Smooth, self securing piston chamber for accurate guiding of piston-disk assembly.
3. Forged steel piston, large diameter to prevent slamming.
4. Cast steel body, proportioned to minimize cross currents. Integrally cast guide ribs are streamlined and cored to increase flow capacity.
5. Fully threaded alloy steel studs, meeting ASA and ASTM requirements.
6. Forged EValloy (stainless steel) disk. Three-point guidance throughout travel. Centered in seat by bottom lip. Stellite available.
7. Forged EValloy seat. Stellite available. Wrench lugs permit easy removal.



Streamlined, strong and functional! Edward cast steel piston type check valve for long slam-proof service at 600 lb sp.

VIBRATION, clatter and damaging shock to piping are cut to a minimum with Edward piston type check valves.

Cast steel in sizes above 2 in., forged steel in the smaller sizes, they all incorporate exclusively Edward design features that cushion disk action and yet give fast, sure closure.

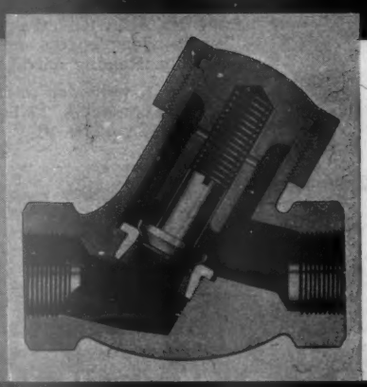
In the cast steel horizontal and angle series, an "hour glass" disk-piston assembly moves in a mirror smooth body piston chamber, guided throughout travel by three streamlined ribs, integrally cast with the body. Thus, kept in proper position to enter the seat at all times, there is no danger of the disk "hanging up."

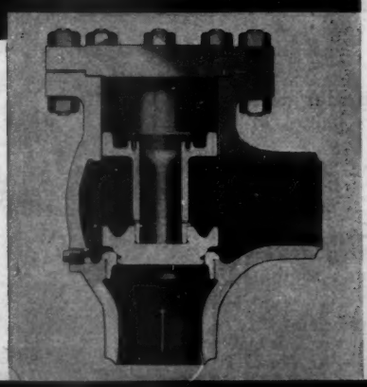
Correct clearance between piston and dashpot, and large piston diameter effectively dampen disk action during sudden flow reversal. Full area streamlined bodies give maximum freedom for flow.

The same principles are used in the design of Edward forged steel check valves, except that in some series a spring is used to aid seating.

For descriptions and dimensions, write for Edward Better Valves Catalog No. 101.

THE EDWARD VALVE & MFG. CO., INC.
1492 WEST 145th STREET
EAST CHICAGO, INDIANA





Edward screwed end forged steel check valves, in sizes ¼ to 2 in., give same freedom from excessive vibration as larger Edward check valves. Spring loaded forged steel checks may be installed in horizontal or vertical lines. For 150 to 6000 lb.

Edward angle check construction is illustrated by 900 lb sp valve above, which has bevel welding ends. Socket or bevel welding ends are available, as well as flanged ends. Integral Stellite seats, and Stellite disks can be furnished, too.

EDWARD *Steel* CAST AND FORGED **VALVES**

dices are lower for position 1, higher for position 2, and then fall as the point of unsaturation passes on toward the middle of the chain.

The character of the regularities between the physical constants and structure when applied to all the isomers of a given family are well illustrated by the boiling-point relationships between the hexenes and hexanes.

The difference between the boiling points of the hexenes and the corresponding hexane are shown in the last column of Table 2. The change in boiling point caused by converting tetramethylethane to tetramethylethylene, an olefin of Type 5, is large and positive—this difference of the olefin finally reaching large negative values for the hexenes of Type 1. The four butylethylenes obey the usual boiling-point rule "the more highly branched the alkyl group, the lower the boiling point." Not only is this true; but, in general, the lower the boiling point, the greater the lowering caused by the introduction of the double bond.

The hexenes of Types 4 and 5 at the top of the table show the effect of an accumulation of methyl groups around a double bond. This effect was first pointed out by Pawlow,[3] who called attention to the fact that "an olefin may be branched in such a way as to cause an increase in its boiling point."

These regularities are still more obvious when one studies the difference produced by introducing a point of unsaturation into the isomeric heptanes. Table 3 shows the differences in the boiling points, densities, and refractive indices first for the heptenes of Type 1, and second for those heptenes having a gradual accumulation of methyl groups about the double bond.

The boiling points of the olefins of Type 1 are lower than those of the corresponding saturated hydrocarbons. The difference is large when the point of unsaturation lies close to the point of branching, and becomes progressively smaller as the point of branching recedes down the chain. The densities and refractive indices of the olefins are in all cases greater than those of the corresponding paraffin, the difference being small when the boiling-point difference is large and negative. As the negative boiling-point difference becomes less, the changes in density and refractive index become progressively greater, the alternation in the three physical constants being regular and roughly parallel. As methyl groups accumulate around the double bond, the boiling points of the olefins become greater than those of the parent paraffins—the differences increasing with the number of methyl groups. Simultaneously, the differences for the density and refractive indices continue to increase, reaching a maximum in the most highly methylated derivative, trimethylethylethylene.

In an earlier paper[4] we sought to coordinate the physical constants and structure of the simple paraffins, olefins, and diolefins. The present paper strengthens and extends the views there expressed. The 2 and 3 positions of a paraffin chain are key positions from the standpoint of physical-constant modification.

The effects of structure on physical constants may be summarized as follows:

Boiling Points

Branching in a paraffin hydrocarbon always lowers the boiling point below that of the corresponding normal isomer. A methyl group in position 2 lowers the boiling point several degrees, and two such methyl groups lower it still further—the total sometimes being more than double that produced by the first methyl group. The methyl group in position 3 is apparently counterbalanced by the methyl group at the end of the chain (position 1). The lowering, therefore, is

FASTENINGS YOU CAN TRUST

1. Application is fast and fool-proof...
Their locking action is immediate and automatic... no pins, no washers, nothing to forget.

2. Grip is positive, yet resilient...
Threads of nut and bolt are held in contact under constant cushioned pressure. The nuts stay put.

3. The locking element does not fail...
Made of non-metallic, non-fatiguing material, it cannot be broken down by vibration or prolonged hard service.

There are more Elastic Stop Nuts on America's airplanes, tanks, guns, Naval vessels, and production equipment, than all other lock nuts combined.

» Write for folder explaining the Elastic Stop self-locking principle

ELASTIC STOP NUT CORPORATION • 2362 VAUXHALL ROAD • UNION, NEW JERSEY

WITH THE RED LOCKING COLLAR . . . SYMBOL OF SECURITY

THROUGHOUT THE OIL FIELDS

Operators are enjoying these benefits on salt-water lines and lead lines with J-M Transite Pipe...

HIGH CORROSION-RESISTANCE. Transite's asbestos-cement composition means long service with minimum upkeep.

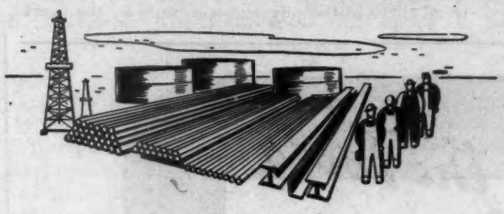
LOW HANDLING COSTS, because Transite is made of asbestos and cement, unusually light in weight.

FAST INSTALLATION, the result of Transite's long lengths and simple assembly. Readily salvaged, too.

For details, write for catalog DS-320. Johns-Manville, 22 East 40th Street, New York, N. Y.

JM Johns-Manville
TRANSITE PRESSURE PIPE
For salt water disposal systems and for lead lines

12 WAYS
TO CONSERVE STEEL, MAN HOURS AND TIME
in drilling and production



1. Use Patterson - Ballagh Drill Pipe and Casing *Protectors* to increase pipe life, reduce power consumption and speed up drilling time.

2. Use Patterson-Ballagh *Stabilizers* in open hole to protect pipe and drill stems and to assure straighter hole.

3. Use *Kelly Sub Protectors* to relieve shock and vibration and to increase life of upper string.

4. Use *Wire Line Guides* to remove the whip so the line will spool evenly.

5. Use *Pipe Wipers* to clean the drill pipe, or tubing, coming up out of hole. Crews work better and safer with clean floors. Prevent the inadvertent dropping of tools in the well.

6. Use *Safety Swivel Bail Bumpers* to prevent the pounding of elevator links against swivel. Heavy rubber cushions the bails.

7. Use *Kelly Wipers* to exclude the mud that causes premature destruction of valuable rollers.

8. Use *Wire Line Wipers* to clean the line coming out of hole when swabbing or coring.

9. Use *Super-Universal Mud Guns* to thoroughly agitate the mud in pit, improving the mixture.

10. Use *Tubing Protectors* made of special oil-resistant plastic to eliminate costly collar wear caused by tubing pulsations.

11. Use *Rod Style Sucker Rod Protectors* to prevent rapid wear of rod couplings in crooked or slanting wells.

12. Use *Sucker Rod Wipers* for cleaning the rods as they come out of the well, without hindrance to the crew's operations.

RUBBER MUST BE USED

If it were not for rubber, thousands of tons more of steel would be needed for this year's drilling operations; hundreds of our deep wells would not be completed; thousands of additional men would be needed to maintain present operation. Judicious use of rubber for Protectors and other oil well equipment is a step toward victory.

PATTERSON-BALLAGH CORP.

PATTERSON BALLAGH OIL FIELD NECESSITIES
"Best bet yet"

CONSERVING VITAL RUBBER

We of Patterson-Ballagh are mindful of the tremendous responsibility imposed on our Products of Rubber—to get the most life out of every ounce of vital rubber used. We have been able to meet the needs of the industry without impairment of quality. Fresh stocks ready to ship.

LOS ANGELES—HOUSTON—NEW YORK CITY

not so great as that produced by substitution in position 2. Two methyl groups in position 3 give a still greater lowering.

When a point of unsaturation is introduced into the paraffin structure in the α-position (1-2), the boiling point also is lowered by several degrees. The double bond in the β-position (2-3), however, lowers the boiling point only slightly—the effect again apparently being counterbalanced by the methyl group at the end of the chain. When these two structural modifications are simultaneously present with the double bond in the (1-2) position, and an accumulation of methyl groups on carbon atom 3, the effects are additive, producing a maximum lowering in the boiling point.

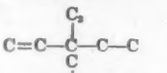
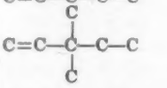
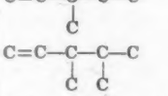
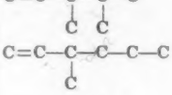
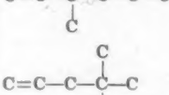
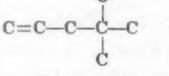
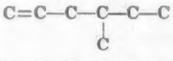
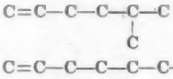
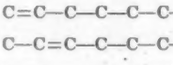
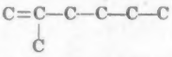
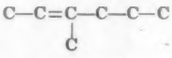
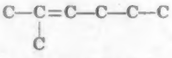
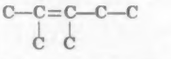
Density and Refractive Index

It has been shown[3] repeatedly that methyl groups in position 2 tend to lower both density and refractive index. An accumulation of two methyl groups in this position is still more effective. A methyl group in position 3, however, sharply increases both the density and the refractivity, and two methyl groups are more effective than one.

In general, all unsaturated compounds are more dense and more refractive than the parent saturated hydrocarbon. When the point of unsaturation is in the α-position, and there is an accumulation of methyl groups on carbon atom 3, the two factors neutralize each other—with the result there is a minimum change in density and refractivity. When the double bond is surrounded by methyl groups, as in olefins of Types 3, 4, and 5 (see Tables 2 and 3), the net result is an increase in all three of the physical constants by the maximum amount. The effect produced is as though the methyl groups surrounding the point of unsaturation serve to multiply the effect of a double bond in the β-position.

Double bonds in the conjugate position give strong increases to all three of the physical constants. Two methyl groups in the conjugate position (on adjacent carbon atoms) greatly increase the density and refractive index, although the branching still lowers the boiling point.

TABLE 3—HEPTENES VS. HEPTANES

Heptene structure	Boiling point (°C.)	d_4^{20}	n_D^{20}
	—10.0	+0.0014	0.0061
	—9.1	+0.0024	0.0080
	—9.3	+0.0054	0.0069
	—7.7	+0.0078	0.0083
	—7.5	+0.0079	0.0093
	—5.3	+0.0099	0.0098
	—4.2	+0.0147	0.0103
	—4.65	+0.0157	0.0121
	—0.15	+0.0197	0.0164
	+1.3	+0.0211	0.0189
	+1.4	+0.0262	0.0193
	+4.5	+0.0300	0.0224
	+8.0	+0.0310	0.0291

As the characteristic structural group of a paraffin or olefin becomes more complex, a larger number of carbon atoms is involved. Once the characteristic structure is completed, continued lengthening of the chain develops the physical-constant curve in a perfectly normal manner.

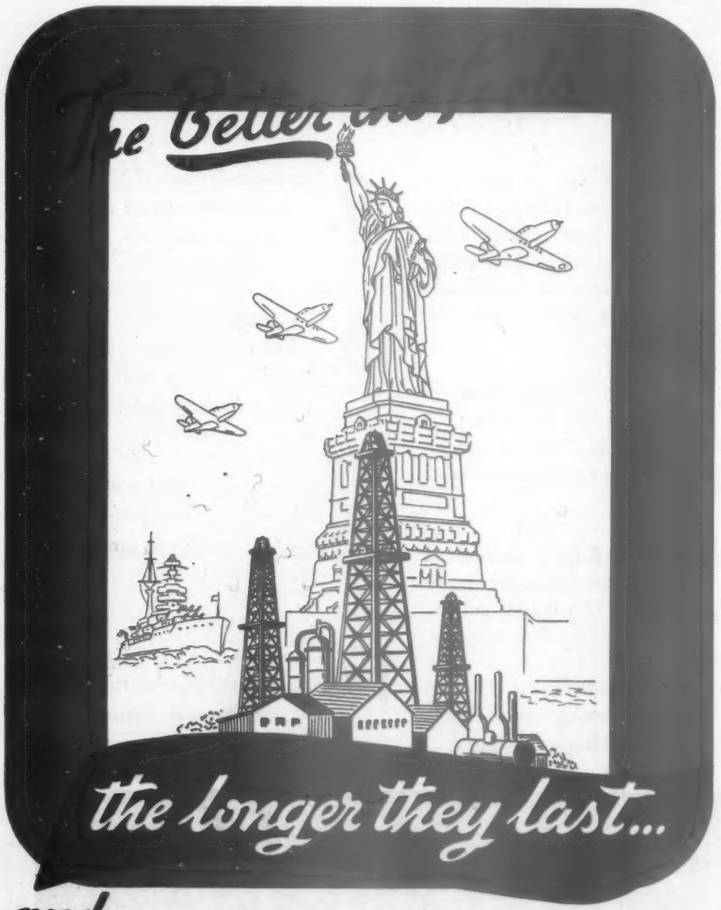
References

1. (a) Egloff, Sherman, and Dull, J. Phys. Chem. 44, 730 (1940). (b) Deanesly and Carleton, J. Phys. Chem. 45, 1104 (1941). (c) Francis, Ind. Eng. Chem. 33, 554 (1941). (d) Calingaert and Illadky, J. Am. Chem. Soc. 58, 153 (1936). (e) Kurtz and Ward, J. Franklin Inst. 222, 563 (1936); 224, 583 and 697 (1937).
2. Deanesly and Carleton, loc. cit. See also Kauffmann, "Relation Between Physical Properties and Chemical Constitution," Ferdinand Enke, Stuttgart (1920).
3. Pawlow, Ann. 196, 126 (1879).
4. Boord, "Science of Petroleum," 2, 1349 (1938).
5. Edgar and Calingaert, J. Am. Chem. Soc. 51, 1540 (1929).

Chemical Interest Acquired

NEW YORK.—Standard Oil Co. (New Jersey) last week acquired complete ownership of Standard Alcohol Co., purchasing the interest previously held in the chemical concern from National Distillers Products Corp.

The Standard Alcohol Co. was organized in 1932 for the production and distribution of alcohols and other chemicals from petroleum hydrocarbons. One alcohol plant is operated at Linden, N. J., and another at Baton Rouge, La. Standard purchased the National Distillers' interest to more completely integrate chemical operations, the company announced. Consideration involved in the transaction was not disclosed.



and—
THE LONGER THEY LAST the better

The HIGHER STANDARD

It's always been wise to buy the best tools available . . . now it's *vital!* Every day added to the useful life of a piece of oilfield equipment means time and material saved to insure our liberty. Those who, even in normal times, have known that Spang Cable Tools offer a longer period of efficiency, are more grateful than ever now for these "Higher Standard" Tools.

SPANG AND COMPANY • BUTLER, PA.

SPANG NAME IN CABLE TOOLS

Evaluation of Effective

Displacement Pressures for Petroleum Oil-Water Silica Systems

By FRANK C. BENNER, CHARLES G. DODD, and F. E. BARTELL
University of Michigan, Ann Arbor, Mich.

A. P. I.

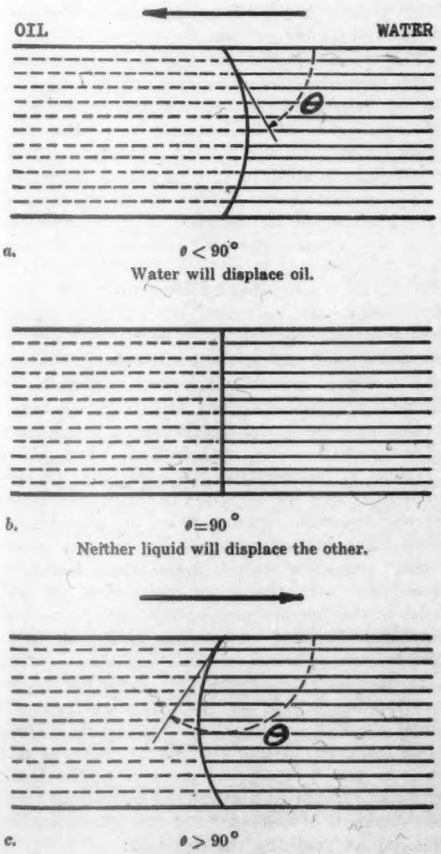
Pressure displacement of oil by water and of water by oil from silica, calculated from contact-angle measurements of crude oil-water systems on silica plates, agreed with actual measurements of pressures for the same crude oil-water systems in packed-silica powder plugs. With all of the crude oils investigated there was an hysteresis of the interfacial contact angle; i.e., the oil-water interface gave one angle against the silica when water was advancing, and another different angle when water was receding. All of the water-receding angles measured were less than 90°, whereas the majority of water-advancing angles were greater than 90°. It is shown that spontaneous displacement of oil by water occurred only when both angles were less than 90°. No spontaneous movement occurred when the angles were on opposite sides of 90°. Spontaneous displacement of water by oil would be expected if both angles were greater than 90°, but such a situation never was found. Probably the most significant fact brought out by the work was that so large a percentage of the oils gave advancing interfacial contact angles greater than 90°, indicating that the surface underlying the oil had become hydrophobic, probably by adsorption of surface-active materials from the crude oil. With such systems, a water drive might leave behind a large quantity of oil adhering to the siliceous material if too rapid a rate of drive were attempted, unless additions to the water of suitable materials for reducing the advancing-water angle could be made.

Paper presented before Division of Production at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

WHEN petroleum is produced from a reservoir, water frequently supplies at least a part of the driving force which moves the oil toward the well bore. This driving force can be supplied by water in two ways: The hydrostatic head on the water underlying the oil in the reservoir accounts for the major part of the water-driving force, but another part may be the result of the tendency of the water to displace oil from the capillary rock formation. This latter displacement force acts favorably only in those cases in which water wets the rock formation to a higher degree than does the oil. It has been assumed tacitly, inasmuch as water is known to wet silica more highly than does oil, that all reservoir-rock formations are wetted to a higher degree by water than by oil. That this assumption does not hold true in some instances has been shown by recent work.[1,2,3,4] It is, therefore, necessary to find out whether, or under what conditions, water wets a particular formation to a higher degree than does the oil of the formation, before it can be determined whether the water drive is being utilized most effectively.

Comparatively little reliable information is available regarding the relative degrees of wetting of reservoir-rock materials by different liquids. To designate the relative degrees of wetting in a series of liquids, it may be stated that the rock material is wetted the more highly by that liquid which causes the greater lowering of free surface energy when its liquid-air interface and a corresponding area of rock-material-air interface disappear to form an area of liquid-rock-material interface. The direct measurement of this free-surface-energy decrease has not as yet been accomplished. The most suitable indirect method for the determination of the wettability (i.e., degree of wetting) of reservoir rock by the reservoir fluids involves the measurement of the angle of contact formed between the solid rock material and the pairs of the reservoir fluids concerned. If the angle of contact between the solid, water, and oil, θ_{owo}, (as measured through the aqueous phase) is less than 90°, it may be said that water wets the rock material to a higher degree than does oil, and that the water spontaneously will force the oil from the rock material. If the contact angle, θ_{owo}, exceeds 90°, oil may be said to wet the rock material to a higher degree than does water, and the oil spontaneously will force the water from the rock material. Should the angle be exactly 90°, no spontaneous movement would occur. These effects are shown diagrammatically in Fig. 1.

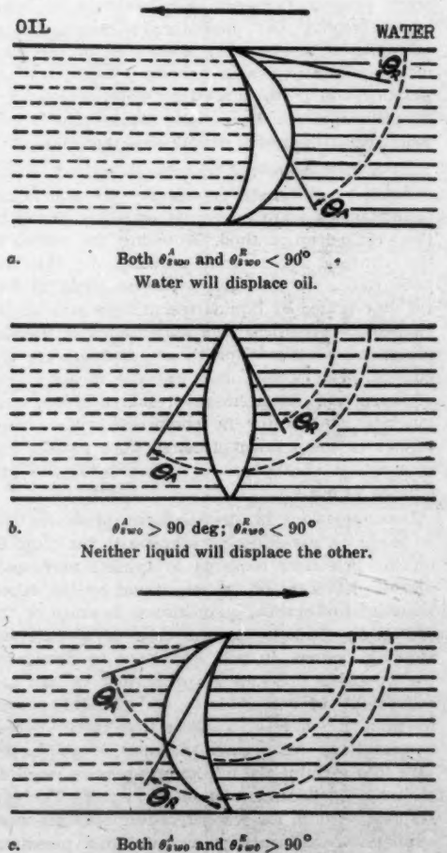
This simple criterion of wettability is correct, and is good in so far as it can be applied, but it is complicated by the fact that the water-advancing angle formed when the water-oil interface is caused to move over a surface originally in contact with oil, θ^{A}_{owo}, is often different from the water-receding angle formed when the same water-oil interface is caused to move over a surface originally in contact with water, θ^{R}_{owo}. This phenomenon of the existence of two different angles, an advancing angle and a receding angle, for a single system is well known, and has been



a. $\theta < 90°$
Water will displace oil.

b. $\theta = 90°$
Neither liquid will displace the other.

c. $\theta > 90°$
Oil will displace water.



a. Both θ^{A}_{owo} and $\theta^{R}_{owo} < 90°$
Water will displace oil.

b. $\theta^{A}_{owo} > 90$ deg; $\theta^{R}_{owo} < 90°$
Neither liquid will displace the other.

c. Both θ^{A}_{owo} and $\theta^{R}_{owo} > 90°$
Oil will displace water.

(*Note:* Arrows indicate direction of spontaneous displacement.)

FIG. 1 FIG. 2

referred to as "hysteresis" of the contact angle. The cause of the hysteresis effect heretofore has been obscure, and none of the explanations which have been offered to account for the hysteresis effect has been accepted generally. Some investigators have held that neither of the angles is an equilibrium angle, but that some intermediate equilibrium angle should exist for the system. Recent work[5,6] has shown, however, that distinct advancing and receding angles do exist; that they are undoubtedly stable angles for the system as it exists under the conditions of their measurement; and that the difference in magnitude of the two angles may be great.

For a given reservoir-rock material, if the two angles, although different, were both less than 90°, it would be unquestioned that water would wet the rock material to a higher degree than would the oil, and there would be spontaneous and continuous movement of water forcing the oil out of the rock material. If the two angles, although different, were both greater than 90°, oil would wet the rock material to a higher degree than would water, and there would be spontaneous and continuous movement of oil forcing water out of the rock material. No systems of this latter type have been reported. If the two angles were so different that they were on opposite sides of 90°, there would be no spontaneous movement of liquid in either direction, and any interpretation of relative wettability would become difficult. Systems of this type do exist; they, in fact, constitute the rule rather than the exception, and such systems will be discussed in this paper.

A diagrammatic representation of the three cases previously mentioned is given in Fig. 2. In each instance the advancing angle is the larger angle (as measured through the water phase).

It has been shown in an earlier paper from this laboratory[6] that other apparently stable angles may be formed with values lying between the stable advancing and the stable receding-angle values. When liquid is added to, or removed from, one of the liquid phases in such manner as to cause alteration of the angle of contact, the new intermediate angle, θ^{I}_{swo}, (see Fig. 3) or

$\theta^{A}_{swo} > 90°$ $\theta^{R}_{swo} < 90°$

FIG. 3

any one of a series of angles thus formed between the two limits, although apparently stable, is not a true stable angle. No movement of the two liquids at their point of contact with the solid will occur until the value of the interfacial angle becomes that of either the stable "advancing" or the stable "receding" angle. The pressure necessary to effect movement of the two liquids at their point of contact with the solid would be that calculated from Equation 1 hereinafter, using the value of the stable advancing or stable receding-contact angle, (i.e., of θ^{A}_{swo} or θ^{R}_{swo}) depending upon which angle represented the condition of the system when movement of the liquid column was initiated. Inasmuch as the advancing and receding displacement pressures are directly proportional to the absolute value of the cosine of the respective contact angles, it is seen that, for a given system, displacement of oil by water may be effected more easily than displacement of water by oil if the difference between 90° and the value of the receding angle is greater than the difference between 90° and the value of the advancing angle, i.e., $90° - \theta^{R}_{swo} > \theta^{A}_{swo} - 90°$.

The interpretation of the effects of hysteresis of the contact angle upon liquid flow in porous materials, as developed in the preceding paragraphs, to our knowledge, has not received consideration heretofore. In the present investigation the effects of hysteresis of the contact angle upon liquid flow were studied by measuring the pressures built up by movement of pairs of liquids in compressed-silica membranes, and by measuring the interfacial contact angles of the same pairs of liquids—one of which was a drop—on silica plates. The hysteresis effect as observed directly with the drop was very marked for nearly all of the crude oils tested. This large effect is believed to be caused mainly by the surface-active materials in the oils. As was stated in an earlier paper,[6] "the solid surfaces, or interfaces, contiguous to the fluid phases become altered through adsorption from the fluids or by the formation of condensed layers of fluid upon the surfaces." Thus the effective solid or immobile surfaces underlying each of the two liquid phases (i.e., the oil and the water phases) become different. The portion of the surface beneath the oil becomes hydrophobic, while that beneath the water remains hydrophilic. Advancing-angle measurements are made with the interfaces of the fluid phases in contact with a solid surface which previously had been underlying an oil phase (hydrophobic), whereas receding-angle measurements are made with the interfaces of the fluid phases in contact with a solid surface which previously had been underlying the water phase (hydrophilic).

The primary object of the present research was to ascertain whether it is possible to determine, from contact-angle data obtained by direct measurements, the approximate magnitude of spontaneous displacement pressures, or the magnitude of the pressures necessary to initiate displacement of petroleum oil by water, or of water by petroleum oil, when these liquids are in contact within the pores of siliceous materials.

As a first step, the interfacial contact angles formed by different petroleum oils and water against silica were measured on silica plates by the sessile-drop method. Knowing the values of the contact angles and knowing the effective pore radius of the given porous silica system (as determined by liquids which form zero angles against air on silica)[7] the magnitudes of the displacement pressures for these systems were calculated. The second step was the measurement of the actual displacement pressures of the various oils and water in compressed-silica membranes of the known effective pore radius, and comparison of the actual values with the calculated values.

Determinations of displacement pressures can be made on pressures spontaneously built up, or on the pressures required to initiate movement and displacement of the one liquid by the other. In order to obtain a quantitative measure of the displacing tendency in the case of a water-advancing system, it was necessary to determine the opposing pressure required just to halt the movement of water into an oil-filled porous medium, i.e., if θ^{A}_{swo} was less than 90°; whereas in case θ^{A}_{swo} was greater than 90°, it was necessary to determine the minimum pressure required to cause displacement of oil by water. The corresponding data for water-receding systems were obtained by measuring the minimum pressures required to cause or to prevent movement of oil into the water-filled porous medium.

The displacement pressure thus measured is related to other properties of the system: oil, water, and reservoir material, by the equation:

$$P = \frac{2S_{wo}\cos\theta_{swo}}{rg} \qquad (1)$$

where: P is the displacement pressure, S_{wo} is the water-oil interfacial tension, θ_{swo} the interfacial angle of contact, r the mean effective pore radius of the porous membrane, and g the gravitational constant.

Comparison of calculated pressures from sessile-drop contact-angle data, obtained using a solid in the form of plates, with measured displacement pressures determined directly in cells packed with the same kind of solid in the form of a fine powder should serve to indicate the validity of the sessile-drop method for the evaluation of wettability of reservoir-rock material, inasmuch as a packed powder membrane approaches in physical condition an unconsolidated sand formation.

Experiments as outlined hereinbefore were carried out. It was found that measurement of interfacial contact angles by a direct method, as by the sessile-drop method, does enable one to determine with reasonable certainty whether spontaneous displacement of the one liquid by the other will occur; also to determine the approximate magnitude of any displacement pressures built up, or even the approximate pressures which may be required to initiate displacement.

Experimental Procedure

Quartz silica was chosen as the solid for use in these investigations, because it represents the major constituent of most reservoir-rock systems. In the determinations of the interfacial contact angles by the sessile-drop method, the silica was used in the form of polished quartz plates. In the experimental determinations of the displacement pressures, the silica was used in the form of ground quartz powder.

The quartz plates for the sessile-drop work were cleaned between experiments by digestion in hot, fuming nitric acid, followed by digestion and rinsing in distilled water; they then were dried at 110° C., and heated at 400° to 450° C. for 3 hours in a muffle furnace before being used.

The ground-quartz powder, 300 to 350-mesh in size, was cleaned by digestion of 1-1 hydrochloric acid, was rinsed copiously with distilled water, was dried at 110° C. and, finally, was heated at 750° C. for 3 hours before being used. The effective mean pore radius of the silica as packed in the displacement cells was 6.86×10^{-4} cm. for one batch, and 5.89×10^{-4} cm. for another batch.

An attempt was made to secure samples of crude petroleum oils from several of the major producing areas in the United States. The sources of the various crudes are indicated at the bottom of Table 1. None of the oils used could be said to be in exactly the condition in which it occurred in the reservoir, inasmuch as all experiments were conducted at atmospheric pressure using "dead" oils. The oil-field brine which had been associated with the given petroleum oil was used as the aqueous phase when such brine was available. Distilled water was used with those oils for which brine was not available.

In the sessile-drop method employed for the determinations of the interfacial contact angles,[8,9] small drops of one liquid were placed on a silica plate immersed in the other liquid (Figs. 4a and 4b). It has been shown previously that small drops of a liquid on a solid form very nearly perfect segments of spheres,[8,9] and that calculations of the contact angle by the equation:

$$\tan\frac{\theta}{2} = \frac{2h}{w} \qquad (2)$$

At All Times

PROTECTION AGAINST CORROSION

IS HIGHLY IMPORTANT
BUT IN TIME OF WAR
IT BECOMES A PATRIOTIC DUTY

The Wide Recognition of the Use of

LIME

TO COMBAT CORROSION IS EVIDENCED BY THE FOLLOWING LIST OF LICENSEES UNDER JENKINS PATENT NO. 2,167,211

Arro Oil & Refining Co.
Ashland Oil & Refining Co.
Atlas Oil & Refining Corp.
Aurora Gasoline Co.
Bareco Oil Company
The Bay Petroleum Corp.
Bell Oil and Gas Company
Ben Franklin Refining Co.
Big West Oil Company
The Canton Refining Company
*Consumers Co-operative Ref's., Ltd.
Continental Oil Company
Cooperative Refinery Association
Cosco Oil Company
Cosden Petroleum Corporation
Cushing Refining and Gasoline Co.
Danciger Oil & Refining Co.
Deep Rock Oil Corporation
The Derby Oil Company
Douglas Oil & Refining Co.
Eagle Oil & Refining Co., Inc.
The ElDorado Refining Co.
Elk Refining Company
El Tejon Oil & Refining Corp.
Fletcher Oil Company, Inc.
Freedom Oil Company
Glacier Production Company
The Globe Oil & Refining Co.
Home Oil & Refining Co.
Independent Refining Co.
Inland Empire Refineries, Inc.
Johnson Oil Refining Company
Kendall Refining Company
Leonard Refineries, Inc.
Louisville Refining Company, Inc.
*McColl-Frontenac Oil Co., Ltd.
McMurrey Petroleum Corporation
McNutt Oil & Refining Co.
Maico Refineries, Inc.
Mercury Oil Refining Co.
Mid-West Refineries, Inc.
Mohawk Petroleum Corporation
Motor Fuels Corporation
Naph-Sol Refining Co.
The National Refining Company
*North Star Oil Limited
Northwest Refining Co.
Pacific Central Refining Co.
Pacific States Oil Co.
Pana Refining Co.
Panhandle Refining Company
The Pennsoil Company
Quaker State Oil Refining Corp.
Rock Island Refining Co. (Okla.)
Rock Island Refining Corp. (Ind.)
Roosevelt Oil Company
Root Petroleum Company
Rothschild Oil Company
The Shamrock Oil and Gas Corp.
Shell Oil Company, Inc.
Skelly Oil Company
Socony-Vacuum Oil Company, Inc.
Standard Oil Co. (Indiana)
Sunray Oil Company
Talco Asphalt and Refining Co.
United Refining Company
Valley Refining Co.
The Vickers Petroleum Co.
W. T. Waggoner Estate (Rel. Dept.)
H. F. Wilcox Oil & Gas Company
Wilshire Oil Company, Inc.
Wood River Refining Co.

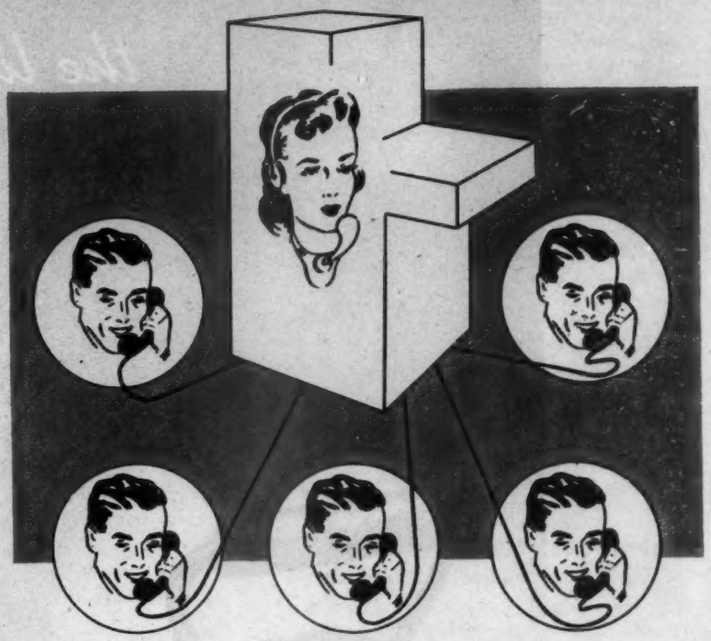
*Licensed under Canadian Patent 274,344

Address All Inquiries To

JENKINS
PETROLEUM PROCESS CO.

20 North Wacker Drive • Chicago, Ill.

Can You Hold a Conference Over Your Present Telephone System?



Look Into the Many Ways Kellogg Can Help You Save Time and Speed Service

These days it's more important than ever for oil, gas and pipe line companies to have efficient, dependable telephone service. How does your communication system measure up to today's requirements? Does it permit conferences between a number of people at widely scattered points? Can all key employees be reached instantly without waste of time or manpower? Can you spread instantaneous alarms by a single operation, anytime during the day or night?

If not, a Kellogg private branch exchange switchboard is a practical necessity. This equipment saves time — the one thing we dare not waste today — by speeding up interdepartmental communications. It eliminates time lost when messages are personally delivered. It helps an organization function more smoothly and efficiently.

This is only one of the many Kellogg developments which can help you keep your telephone system in tune with today's needs. Others are Relaymatic switchboards, for instantaneous inter-communication without the need of an attendant . . . a complete line of dependable telephone parts and apparatus, ruggedly built and able to stand the rigorous demands of oil field service . . . and line supplies of every type required to keep your telephone lines open. Kellogg's field representatives will be glad to discuss any communication problems with you.

KELLOGG
SWITCHBOARD & SUPPLY CO.
6674 So. Cicero Avenue • Chicago, Illinois

TURN IN YOUR SCRAP
TO WIN THE SCRAP!

TWO HELMETS CAN BE MADE FROM THIS SMALL AMOUNT OF SCRAP

Scrap drives throughout the nation have brought in scrap by the millions of tons and have helped to keep the open hearth and electric furnaces busy. But still more is needed and there must be a constant stream pouring in to maintain production.

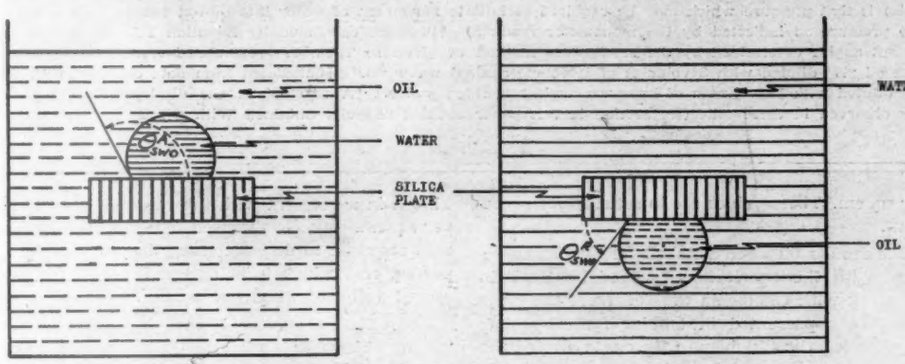
We have skimmed the cream off the top — now let us all look still further into the stock pile — For Victory.

REED ROLLER BIT CO.
HOUSTON, TEXAS,

is justified. In this equation θ is the angle of contact, h is the height of the drop, and w is the diameter of the drop in the plane of the solid surface. "Advancing" interfacial angles, $\theta^{A}_{s,wo}$, were obtained by placing water drops on a plate immersed in oil, and "receding" interfacial angles, $\theta^{R}_{s,wo}$, were formed by placing oil drops on the under side of a quartz plate immersed in water. The dimensions of the drops were measured by means of a micrometer eye piece attached to a low-power microscope. Each of the contact-angle values recorded is the mean of measurements on at lease five drops on a single plate. The average deviation from the mean of measurements was ±2°. All determinations were made at room temperature, approximately 25° C.

found that oils "B" and "C" were too opaque to permit determination of advancing angles by this method. These oils therefore, were, diluted with pure isooctane until they transmitted sufficient light to allow observation of the water drops which were placed on the silica plates immersed in the oil-isooctane solution.

The value of 30°, for water advancing against isooctane, $\theta^{A}_{s,wo}$, given for comparison, shows that water wets silica to a much higher degree than does isooctane, and indicates that water should displace spontaneously isooctane from silica. The petroleum oils investigated showed quite different behaviors. In only one instance, i.e., with oil "A" was the water-advancing interfacial angle less than 90°, indicating greater wetting by water than



a. Method used for obtaining advancing angles.

b. Method used for obtaining receding angles.

FIG. 4

The pressure-of-displacement technique used was essentially the same as that described by Bartell and Benner.[10] In the present work certain modifications in procedure were made so that distinct "advancing" and "receding" interfacial contact angles within the pores would surely be obtained. Manometers were attached to the oil end of the system. For those systems in which water tended spontaneously to displace oil from the pores of the packed-powder membrane, the pressure built up by the advancing-water interface corresponded to that of an advancing contact-angle system. In systems for which water did not tend spontaneously to displace oil from the powder, it was necessary to impose a "negative" pressure on the system to cause water to move into the oil-filled portion of the silica membrane and thus obtain a water-advancing system. Water-receding displacement pressures were obtained by imposing on the cell a "positive" back pressure sufficiently great to cause movement of oil into the water-wet portion of the silica membrane. In none of the systems investigated did oil spontaneously displace water from the silica. All measurements were made in an air bath held at 25° C. ±0.1° C.

Interfacial tensions of the crude oil-water systems used were determined by the ring method, using an interfacial-tension balance. The correction factor of Harkins and Jordan[11] were applied in the calculations. Several of these determinations were checked by the pendent-drop method,[12] and good agreement was obtained.

With some of the crude oil-water systems employed, a "skin" was formed at the interface (as described hereinafter), and this prevented a satisfactory determination of the interfacial tension by the ring method. The interfacial tensions of these systems were determined solely by the pendent-drop method.

Sessile-Drop Data

Data for the advancing contact angles between silica, oils, and water drops, as determined by the sessile-drop method, are given in Table 1. It was

by oil. With the remainder of the oils, the water-advancing contact-angle values ranged from 99° to 165°, indicating greater wetting by the oil than by the water. It seems reasonable to assume that the advancing contact-angle values obtained for the various oils diluted with isooctane are at least no larger than the values which would have been obtained for the undiluted crudes. The time factor in these advancing-angle measurements is, apparently, not of critical importance; nevertheless, in order somewhat to simulate natural conditions, the plates were allowed to stand in contact with the oil for a period of several days before the water drops were placed on the surface of the solid.

Data for the receding contact angles between silica, oils, and water, as measured by the sessile-drop method, are also given in Table 1. The 0° angle for water against isooctane, given for comparison, indicates that, when a drop of isooctane is brought into contact with a silica surface covered with water, there is no tendency for the isooctane to displace the water from the silica surface. For the oils studied, the receding interfacial angles all were less than 90°, indicating that, when the water is receding from the silica surface, the water wets this surface more highly than do any of the oils investigated. Oil-field brine gave results little different from those obtained with distilled water.

It may be noted, in general, that the advancing contact angles for the systems studied show greater variation between the different oils than was observed for the receding contact angles. This indicates that an "advancing" angle will give a better indication of the specific wetting power of an oil than will a receding angle. It is interesting to note that the oils "A" and "D" from the Pennsylvania fields show radically different advancing angles than oils "B" and "C" from the Mid-Continent and California areas, respectively.

TABLE I—INTERFACIAL CONTACT ANGLES
Sessile-Drop Method

Crude oil or organic solution—	Water	Interfacial contact angle: Advancing (deg.)	Interfacial contact angle: Receding (deg.)
Isooctane	Distilled	30	0
Oil A*	Distilled	77	36
Oil B	Water B	...	35
Oil B	Distilled	...	36
(Oil B + 3 volumes isooctane)	Water B	165	..
Oil C	Distilled	...	43
(Oil C + 10 volumes isooctane)	Distilled	156	43
Oil D	Distilled	99	34
Oil E	Distilled	128	50
Oil F	Water F	...	23
(Oil F + 5 volumes isooctane)	Water F	141	..
Oil G	Water G	156	37
Oil H	Water H	...	23
(Oil H + 3 volumes isooctane)	Water H	141	..

*Oil A—Bradford, Pa., Hazel M. Seese farm.
Oil B—Oklahoma City, Wilcox.
Oil C—Los Angeles, Calif. (Fruitvale field).
Oil D—Bradford, Pa., Drake farm.
Oil E—Saginaw, Mich., Crystal pool.
Oil F—East Texas.
Oil G—Billings, Wilcox (Oklahoma).
Oil H—Earlsboro, Wilcox, Seminole field (Oklahoma).

Discussion of Experimental Data Obtained by the Pressure-Displacement Work

The advancing and receding displacement pressures can be calculated for any given system by means of Equation 1 if the interfacial tension, the effective mean pore radius of the packed sand, and the corresponding contact angles are known. The displacement pressures for five of the petroleum oil-water systems investigated were calculated by using the contact-angle values obtained by sessile-drop measurements, and were checked experimentally by the pressure-of-displacement work. The results of these experiments are given in Table 2.

It will be noted that all of the advancing and receding displacement pressures measured were substantially in agreement with those calculated by the use of the sessile-drop data. Each pressure reported is the average of results of two or more determinations made with separate cells. Perhaps the agreement is better than should have been anticipated in view of the fact that even the interfacial-tension values of these crude oils against water show anomalous behavior when observed over a period of time.

While the interfacial-tension values were being determined by the pendent-drop method, it became evident that some of the crude oils contained large quantities of surface-active materials. When drops of these crude oils first were formed in the pendent-drop apparatus in contact with brine or distilled water, the drop could be enlarged or contracted at will. After the drop had aged for 30 minutes to 1 hour, however, a thin tough 'skin" appeared at the interface, and the shape of the drop was distorted greatly upon contraction. It was found that the interfacial tensions of these crude oil-water systems varied from 1 to 5 dynes per centimeters when observed over a period of 2 or 3 days. (The interfacial tensions reported in Table 2 were the approximately constant values reached by these systems after standing for a period of time roughly equivalent to the time taken to reach equilibrium in the displacement cells. The tensions are probably accurate to within 2 dynes in most cases.) The surface-active materials evidently were accumulating at the interface. If this type

of interfacial aging occurs within the pores of the packed cells, the experimentally observed pressures would deviate from 5 to 20 per cent from the calculated values. Again, if there is an appreciable amount of the "skin" formation at the solid-oil boundaries within the packed silica, the effective pore radius might thus be altered.

In addition to the errors introduced in the calculation of pressure-of-displacement values by possible variation or error in the factors used in Equation 1, the attainment of equilibrium or constant pressures probably was affected by viscosity and by the phenomenon of counterflow. Very viscous crudes approached equilibrium pressure slowly. The effect of counterflow in the displacement cells has been discussed by Bartell and Benner,[13] and its possible significance in petroleum production by Benner, Riches, and Bartell,[14] and by Buckley and Leverett.[15]

TABLE 2—COMPARISON OF CALCULATED AND OBSERVED DISPLACEMENT PRESSURES

Crude oil—	Crude-oil-water interfacial tension (dynes per centermiter)	Mean effective pore radius of packed cell (centimeters)	Displacement pressures* (in grams per square centimeter)			
			Advancing		Receding	
			Calculated†	Observed	Calculated†	Observed
Oil A	26	6.86×10^{-4}	+17	+13 to +72	+62	+61
Oil B	21	5.89×10^{-4}	‡—70	—44 to —65	+59	+63
Oil C	22	5.89×10^{-4}	§—69	—56 to —75	+56	+67
Oil D	20	6.86×10^{-4}	— 9	—10 to —19	+49	+54
Oil E	17	5.89×10^{-4}	—36	¶+ 4 to +78	+38	+54

*A positive pressure (indicated as + in table) is that pressure developed spontaneously in the displacement of oil by water, or is that pressure which must be applied in order to initiate displacement of water by oil. (It is a positive pressure as indicated by the manometer reading.) A negative pressure (indicated as — in the table) is that pressure which may be required to initiate movement of water into oil-wet silica. (It is a negative pressure as indicated by the manometer reading.) †Pressure calculated by Equation 1 using interfacial contact angles determined by the sessile-drop method as given in Table 1. ‡Calculated from data obtained with oil "B" diluted with 3 volumes of isooctane against water "B." §Calculated from data obtained with oil "C" diluted with 10 volumes of isooctane against distilled water. ¶A reversal of the displacement tendency was observed in these cells (see section in this paper entitled "Results Obtained With Oil "E").

Results Obtained With Oil "A"

Oil "A" was a light, clear oil from one of the Pennsylvania fields. The interfacial-contact-angle values obtained with it by the sessile-drop method were 77° for θ^{A}_{swo}, the advancing angle; and 36° for θ^{R}_{swo}, the receding angle. As both advancing and receding-angle values were less than 90° (as illustrated in Fig. 2*a*) it could be concluded that water should displace spontaneously this oil from silica. The validity of this conclusion was confirmed by the observed behavior of oil "A" in displacement cells.

Calculations showed that, in a compressed-silica membrane with a mean effective pore diameter of 6.86×10^{-4} cm. (the mean diameter of the pores of the compressed-silica powder used in the corresponding displacement test), the pressure which should be built up spontaneously by an advancing water column was approximately 17 g. per sq. cm. The pressures actually built up in the pressure-of-displacement cells ranged from 13 to 72 g. per sq. cm. The maximum pressure developed in the displacement of this oil by water was observed after the cell had been allowed to build up pressure undisturbed over a period of from 1 to 3 weeks. Apparent equilibrium was attained very slowly in all the cells containing oil "A." (On the other hand, oils "B," "C," and "D," all reached maximum pressures and apparent equilibrium in from 1 to 3 days.) The calculation of the receding displacement pressure from sessile-drop measurements, (i.e., the pressure which should be required to displace water by oil) gave a value of 62 g. per sq. cm., which is in good agreement with the observed value of 61 g. per sq. cm.

Results Obtained With Oil "B"

Oil "B" was obtained from an Oklahoma City field. This crude oil was quite opaque, and it was necessary to dilute it (with three parts of isooctane) before the sessile-drop measurements of the advancing angle could be made. The advancing angle, θ^{A}_{swo}, as measured against the Oklahoma City brine, was 165°; and the receding angle, θ^{R}_{swo}, was 35° against the associated brine, and 36° against distilled water. As the two angles lie on opposite sides of 90° (see Fig. 2), it would be predicted that no spontaneous displacement of oil by water or of water by oil would occur. This prediction was confirmed by displacement-cell tests.

The calculated pressure required for the displacement of oil by water (i.e., the advancing displacement pressure) was 70 g. per sq. cm. The observed pressures ranged from 44 to 65 g. per sq. cm. The calculated pressure required for the displacement of water by oil was 59 g. per sq. cm., as compared with the observed value of 63 g. per sq. cm. These values are in satisfactory agreement.

The results obtained with oil "B" are in agreement with the conclusions reached by Katz[8] in his work with Oklahoma City oil from the same field. Data presented in tabular form by Katz showed that the Oklahoma City crude altered the surface of samples of dry, clean outcrop sand to the extent that extraction with benzene for 30 hours, or washing with natural gasoline, did not clean the surface of the sand sufficiently well to permit tap water to displace kerosene from its surface. It was concluded that oil production by water drive would not be a feasible means of secondary recovery from this sand.

Results Obtained With Oil "C"

Oil "C" was obtained from a Los Angeles, Calif., field. This crude oil was very dark and viscous. Ten parts of isobutane were required for dilution to render the oil sufficiently transparent to make possible measurement of the advancing angle by the sessile-drop method. The advancing angle, θ^{A}_{swo}, measured against distilled water was one of 156° and the receding angle, θ^{R}_{swo}, was 43°. This is an example of the same type of hysteresis as was observed with oil "B," and no spontaneous displacement of either fluid by the other would be expected. No spontaneous movement was observed in the displacement-cell experiment.

The calculated value of the pressure required to effect displacement of oil by water was 69 g. per sq. cm., as compared to a range of 56 to 75 g. per sq. cm. for the observed values. The calculated value of the pressure required to displace water by oil was 56 g. per sq. cm., as compared with 67 g. per sq. cm. for the observed value. This constitutes satisfactory agreement.

It seemed apparent that the surface of the silica was altered by oil "C" in somewhat the same manner—although not exactly the same degree—as it was by oil "B."

Results Obtained With Oil "D"

Oil "D" was from a Pennsylvania field, but differed from the other Pennsylvania oil ("A") in that the advancing and receding angles were on opposite sides of 90°. A value of 99° was obtained for θ^{A}_{swo}, the advancing angle, and a value of 34° for θ^{R}_{swo}, the receding angle. The advancing angle is not much greater than 90°; nevertheless, spontaneous displacement of either fluid by the other would not be expected. Displacement tests bore out this expectation.

Calculation of the pressure necessary to displace oil by water gave a value of 9 g. per sq. cm. This is in agreement with the value of 10 to 19 g. per sq. cm. actually observed. The calculated pressure required to displace water by oil was 49 g. per sq. cm., which is in agreement with the observed value of 54 g. per sq. cm.

The effective surface formed by action of oil "D" on silica was similar to the surfaces formed by action of oils "B" and "C," but was less hydrophobic, as indicated by the lower advancing angle.

Results Obtained With Oil "E"

Oil "E" was a Michigan oil. The effect of this oil upon the silica was strikingly different from the effect of the oils previously reported upon. It apparently produced a quite hydrophobic surface (as indicated by the high advancing angle), but the surface change produced upon the silica appeared not to be so permanent as the changes effected by oils "B," "C," and "D." Water standing in contact with silica altered by oil "E" appeared to remove the effect of the oil so that the surface eventually became as hydrophilic as the surface of silica treated with oil 'A."

Sessile-drop measurements gave values of 128° for the advancing angle, θ^{A}_{swo}, and 50° for the receding angle, θ^{R}_{swo}. By this criterion it would be expected that no spontaneous displacement of either fluid would occur. When measurements of advancing displacement pressures were made, it was found that no spontaneous movement occurred at first; but, after standing for a period of from 2 to 7 days, the surface of the silica had become sufficiently hydrophilic for water spontaneously to displace oil and build up pressures of from 4 to 78 g. per sq. cm.

In the water-receding measurements the interface was moving over silica in contact with water, and the action on the silica was not such an important factor. The observed receding displacement pressure of 54 g. per sq. cm. was in satisfactory agreement with the calculated value of 49 g. per sq. cm.

Results Obtained With Oils "F," "G," and "H"

Oils "F," "G," and "H," from Texas and Oklahoma, all gave advancing and receding angles lying on opposite sides of 90°. Because of the limited quantities of these oils available, no pressure-of-displacement experiments could be run with them.

General Discussion

The fact that all of the crude petroleum oils investigated in the present work exhibited the phenomenon of hysteresis of the contact angle to

Tubes for Tires

Refiners preparing to produce synthetic rubber ingredients can select tubes that provide excellent resistance to oxidation and corrosion, with minimum use of strategic materials. The B&W Croloys provide an ample range of seamless tube alloys for such service.

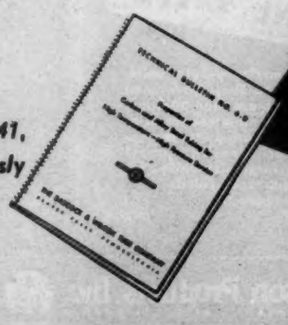
B&W research — still continuing — has amassed a fund of technical data bearing on problems of plant construction and conversion for synthetic rubber requirements. B&W engineers are therefore prepared to furnish prompt assistance in selection of seamless alloy tubing.

As a preliminary step, write on your business letterhead for a free copy of Bulletin No. 6-D*, "Properties of Carbon and Alloy Steel Tubing for High Temperature — High Pressure Service".

Shown above is a tube emerging from the B&W piercing mill. The unique B&W piercing process reveals the slightest flaw in the billet and subjects the steel to a forging action that measurably improves its properties.

This B&W development in the production of seamless alloy tubing is typical of all operations in the B&W specialty-tube mill, where quality always supersedes tonnage and each tube is individually inspected before shipment.

This insures that refiners purchasing B&W Seamless Tubing will always receive tubes of the highest quality procurable.



**This 157-page booklet, issued in 1941, contains valuable data not previously published.*

BABCOCK & WILCOX TUBES

HOT FINISHED ALLOY STEELS — COLD DRAWN CARBON STEELS

THE BABCOCK & WILCOX TUBE COMPANY
BEAVER FALLS, PA.

TA-1210

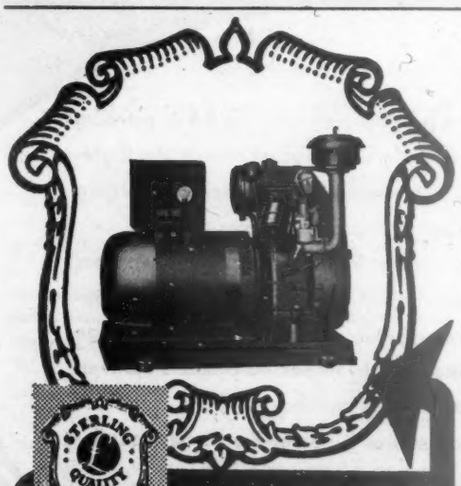
PAGE FENCE

America's First Wire Fence — Since 1883

BULWARK AGAINST TAMPERING WITH MOTOR FUEL FACILITIES ● Petroleum products are more important than ever before. Production and handling facilities must be protected against hostile trespassers. Safeguarding petroleum properties has been a major function of sturdy Page Fence since J. Wallace Page originated woven wire fence in 1883, and founded the company which has been a leader in important fence developments. Safeguarding the fence investment through localized, responsible engineering and erecting service is also a Page achievement. More than 100 factory-trained, long-experienced local firms which own their own plants, make up the PAGE FENCE ASSOCIATION, Headquarters: Monessen, Pennsylvania.

VICTORY FIRST
At the Page mills, men, machines and materials are on an all-out schedule for production of fence to protect plants working on Government orders

PRODUCT OF PAGE STEEL & WIRE DIVISION—AMERICAN CHAIN & CABLE COMPANY, INC., BRIDGEPORT, CONN.



STERLING QUALITY

You'll Get BETTER RESULTS with STERLING

HOISTS - PUMPS - LIGHT PLANTS

Today, more than ever, it's important that construction equipment be *simple, dependable and rugged.* With thousands of new men in Defense Work and Defense Construction . . . every piece of equipment must be easy to operate and efficient. That's why Sterling's Tried and Proven Design makes Sterling Hoists, Pumps and Lighting Plants the choice of largest contractors everywhere.

Get the Sterling Habit . . . Write for literature and prices today!

STERLING MACHINERY CORP.
405-13 SOUTHWEST BLVD.
KANSAS CITY, MISSOURI

Burke-Greis Oil Corporation

Producers of Petroleum

Cosden Bldg.
Tulsa - - - - Okla.

Thompson ENGINE VALVES

Thompson Heavy-Duty Engine Valves and Seats have been used for more than 20 years to reduce maintenance with longer operating life. Thompson specializes in highest quality large size valves for all engine types. Full details on request.

Thompson Products, Inc.

a greater or lesser degree leads one to suspect that most crude oils contain surface-active constituents, i.e., heteropolar molecules or colloidal materials which become adsorbed at the interfaces. Adsorption of these materials alters the surface of the reservoir material, and it is this altered surface which underlies the advancing water. Advancing-water angles are, therefore, better criteria of the wettability of a reservoir material than are receding angles where the surface involved has not been in contact with the oil.

Probably the most significant fact brought out in this work is that so large a percentage of the oils gives advancing interfacial contact angles greater than 90°. This indicates that, in effect, the immobile surface underlying these oils is decidedly hydrophobic, and that water will not displace spontaneously the oil from such surfaces. This situation should receive further and detailed investigation. Of importance would be the determination of the relative amounts of oil which would be retained as adhering films by such surfaces during the process of water drive. It seems likely that the amount of oil retained would be related definitely to rate of drive.

It is probable that, in those systems in which the advancing angle is less than 90°, almost complete oil recovery would be possible, provided a suitable rate of drive were employed.

A knowledge of the magnitude of the interfacial contact angles of a given petroleum oil system should enable one to predict the ease with which displacement of the oil might be effected.

Addition to the water of even minute amounts of materials which would decrease the magnitude of the advancing interfacial contact angle to a value of less than 90° might prove to be of tremendous aid in effecting oil displacement by water.

It seems likely that there may be some correlation between the magnitude of hysteresis effect and the general geographical location of the field from which the crude oil is obtained. Further study is necessary before any definite statements can be made on this subject. In this connection it is interesting to note, however, that two Pennsylvania crude oils differed considerably in their displacement behavior.

Summary

1. The relative wettability of reservoir rock by crude petroleum oils and by water appears to constitute a more complex problem than heretofore has been generally assumed. Certain constituents of the oils, even though present in minute amounts, may influence greatly the degree of wetting of the solid by the oil.

2. In this investigation an evaluation of relative wetting of reservoir rock by reservoir fluids has been attempted by the measurement of contact angles formed by petroleum oils and water on solid-silica plates. Displacement pressures calculated from the contact-angle data were found to be in reasonable agreement with displacement pressures actually observed with the petroleum oils and water in packed-silica powders.

3. A study was made of both "advancing" and "receding" contact angles for a series of petroleum oils and water on silica. Advancing interfacial contact angles were found to vary over a wide range for the different systems studied, in some instances being less and in other considerably greater than 90°. Were the advancing angle alone to be used as a criterion of wetting, it would appear that, in some systems, water wets silica to a greater degree than does oil, but in other systems the converse is true.

4. It was found that receding interfacial contact angles of the systems observed invariably assumed values of less than 90°. By this criterion silica appeared to be better wetted by water than by oil.

5. The advancing interfacial contact angle is be-

T-N-T → → *Our* LETTER TO THE AXIS

THE final "T" in T-N-T is Humble's letter to the Axis. That "T" stands for Toluol which we are manufacturing in large quantities. It puts the bang into American bombs, shells and torpedoes that are blasting the Axis forces on many fronts. It's a letter the Axis has received many times and will receive many times more.

TOLUOL FROM PETROLEUM

45 days before Pearl Harbor we made our first shipment of Toluol—the culmination of years of research and development during which time the secret of making Toluol in commercial quantities from petroleum was discovered. Humble's plant went into production ahead of schedule and production has continued ahead of schedule. For this Humble was awarded the Army-Navy "E"—*the first oil company in the nation to be so honored.*

OTHER WAR PRODUCTS FROM PETROLEUM

Toluol is only one of the war products Humble is processing from petroleum. Up in the skies, high-octane Humble Aviation gasolines give speed and power to our fast pursuit planes and deadly bombers. Engines hum smoothly on Humble Aviation oils, and planes land and taxi back to hangars on runways built of Humble asphalt.

Humble protective coatings preserve our war machines from corrosion, on land and sea those machines thunder into action on fuels and lubricants from Humble—and before too long they will roll on rubber from Humble's giant synthetic rubber plants now under construction.

HUMBLE INDUSTRIAL PRODUCTS

On the Industrial front, Humble continues to serve with fine lubricants and powerful fuels—Rust-Ban* protective coatings, petroleum solvents, Thredkote* thread compounds, Breaxit* emulsion breakers, and other standard and specialized petroleum products. This, we feel, is also a part of our war effort, an effort to which all our energies are directed, with VICTORY as the sole aim.

* Trademarks Reg. U. S. Pat. Off.

For high achievement in the production of war equipment.

HUMBLE

HUMBLE OIL & REFINING COMPANY

13,000 Texans United in the War Effort

As Easy to Specify as They Are to Install
DRESSER COUPLINGS SIMPLIFY BOTH PIPE AND JOINT SPECIFICATIONS
Advantage No. 5 of 12 proved advantages listed in box below.

Check THESE 12 PROVED ADVANTAGES THAT ONLY DRESSERS GIVE YOU

1. Dresser Couplings eliminate all uncertainty in joint-making.
2. Dresser Couplings permit use of local, untrained labor.
3. Dresser Couplings provide the only time-proved method of absorbing expansion and contraction.
4. Dresser Couplings give greater speed.
5. Dresser Couplings simplify both pipe and joint specifications.
6. Dresser Couplings can be installed regardless of weather, wind, or rain conditions.
7. Dresser Couplings eliminate "fussy" operations.
8. Dresser Couplings permit pipe deflection for curves and grades with straight pipe.
9. Dresser Couplings reduce cost of supervision and inspection.
10. Dresser Couplings cut maintenance costs.
11. Dresser Couplings are fool-proof, strong, *permanently* tight.
12. Dresser Couplings eliminate health and fire hazards.

Dresser Couplings not only save time *during* pipe-line construction, but also *before* construction! Dressers simplify specifications amazingly. Special preparation of pipe-ends, extra parts for the pipe, special requirements for jointing procedure, coupon testing, "follow-up" instructions, etc., are all eliminated. Instead, the short, concise statement, "Plain-end pipe with Dresser Couplings," just about takes care of the entire matter. A short paragraph against pages of detailed specifications.

When your next pipe-line project is in the specification stage, prepare for fast action. Specify Dresser Couplings.

DRESSER MANUFACTURING COMPANY • BRADFORD, PA.

DRESSER PIPE COUPLINGS

Save Labor • Save Time • Save Worry—with Dressers

lieved to be a better indication of the hydrophilic or hydrophobic nature of the reservoir material containing the oil than is the receding angle.

6. The "hysteresis" effect was very pronounced in nearly all of the systems studied. For most of the systems, the silica appears to have dual wetting characteristics, inasmuch as the receding contact angle is less than 90°, whereas the advancing contact angle is greater than 90°.

7. The results from this research indicate that spontaneous displacement of oil from the underlying solid by water should occur only in those cases where in both the advancing and the receding angles are less than 90°; that spontaneous displacement of water by oil should occur if both angles are greater than 90°; and that no spontaneous movement should occur where the two angles are on opposite sides of 90°.

8. It appears that, in the majority of cases, measurement of the contact angles formed on a silica plate between a petroleum oil and water will serve as a fairly reliable guide for the determination of the displacement tendencies of oil by water or of water by oil.

9. The results obtained give fairly definite proof that crude petroleum oils contain constituents which become adsorbed on siliceous surfaces, causing those surfaces to assume hydrophobic properties.

References

1. R. G. Nutting, 'Some Physical and Chemical Properties of Reservoir Rocks Bearing on the Accumulation and Discharge of Oil," Problems of Petroleum Geology, Am. Assoc. Petroleum Geol., 825-32 (1934).
2. K. H. Andresen, discussion of paper on: "Nature and Importance of Surface Forces in Production of Petroleum," Drilling and Production Practice, American Petroleum Institute, 447 (1938).
3. D. L. Katz, "Possibilities of Secondary Recovery for the Oklahoma City Wilcox Sand," Petroleum Technology 4 (6) 17 (1941).
4. F. C. Benner and F. E. Bartell, "The Effect of Polar Impurities Upon Capillary and Surface Phenomenon in Petroleum Production," Drilling and Production Practice, 341 (1941).
5. F. E. Bartell and P. H. Cardwell, "Reproducible Contact Angles on Reproducible Metal Surfaces: 1—Contact Angles of Water Against Silver and Gold," J. Am. Chem. Soc., 64, 494 (1942).
6. F. E. Bartell and P. H. Cardwell, "Reproducible Contact Angles on Reproducible Metal Surfaces: 2—Interfacial Contact Angles Between Water and Organic Liquids on Surfaces of Silver and Gold," ibid., 64, 1530 (1942).
7. F. E. Bartell and F. L. Miller, "Degree of Wetting of Silica by Crude Petroleum Oils," Ind. Eng. Chem., 20, 738 (1928).
8. G. L. Mack, "The Determination of Contact Angles From Measurements of the Dimensions of Small Bubbles and Drops: 1—The Spheroidal Segment Method for Acute Angles," J. Phys. Chem., 40, 159 (1936).
9. G. L. Mack and D. A. Lee, "The Determination of Contact Angles From Measurements of the Dimensions of Small Bubbles and Drops: 2—The Sessile-Drop Method for Obtuse Angles," ibid., 40, 169 (1936).
10. F. E. Bartell and F. C. Benner, "Adsorption at Solid-Liquid Interfaces," J. Phys. Chem., 46, (in press) (1942).
11. W. D. Harkins and H. F. Jordan, "A Method for the Determination of Surface and Interfacial Tension From the Maximum Pull on a Ring," J. Am. Chem. Soc., 52, 1751 (1930).
12. J. M. Andreas, E. A. Hauser, and W. B. Tucker, "Boundary Tension by Pendent Drops," J. Phys. Chem., 42, 1001 (1938).
13. F. E. Bartell and F. C. Benner, unpublished: "Wetting and Adsorption Studies of Binary Organic Liquid Systems With Silica by a Pressure-of-Displacement Method."
14. F. C. Benner, W. W. Riches, and F. E. Bartell, "Nature and Importance of Surface Forces in Production of Petroleum," Drilling and Production Practice, 442 (1938).
15. S. E. Buckley and M. C. Leverett, "Mechanism of Fluid Displacement in Sands," Petroleum Technology, 4 (3) 9 (1941).

Equipment-Export Form Changed

WASHINGTON, D. C.—Instructions for filling out From PD-311, revised, which is used by oil operators applying for priority assistance for materials sent to foreign countries, were issued November 2 by the War Production Board upon the recommendation of the Office of Petroleum Coordinator for War.

Copies of the instructions may be obtained by writing to the "Director of Foreign Division, Office of Petroleum Coordinator, South Interior Building, Washington, D. C. Ref.: PD-311."

Volumeter Practice in the Petroleum Industry

By E. E. AMBROSIUS* and E. W. JACOBSON†

A. P. I.

THE questionnaire on volumeter practice which was sent to 43 individuals among the major oil companies during the fall of 1941 by the subcommittee for joint A.S.M.E.-A.P.I. volumeter research has yielded much valuable information. Thirty-five replies were received, of which 25 answered the questions. All of the other 10 expressed interest in the work, the majority of reasons for not answering the questions being that their experience was too limited to be able to give any information of value. The replies containing data represented 17 major oil companies, and continued to come in to the committee in the early months of 1942. A study of these data has been made and the purpose of this paper is to present the results of this study.

The first three questions deal with the kind and quantity of products metered, the types of meters used, and variety of products handled by each type. Volumeters are being used for measuring most all liquid petroleum products in varying amounts and this use is increasing very rapidly. Volumeters first came into use in dispensing gasoline and kerosene in service stations. It is in the service-station gasoline dispensing unit that the volumeter has reached its greatest usefulness, at least 95 per cent of all gasoline sold through service stations in this country being measured by the 1-in. size volumeter. Because of its success in the service station, the volumeter has been rapidly developed for gasoline-truck and bulk-station use. Its use has now been extended into measurement of fuel oils, beginning with light domestic distillates on up to the bunker oils, asphalt, naphtha, lubricating oils, crude at well heads and in pipe lines, and recently propane, butane, and mixtures of propane and butane. One company reports the use of 160 volumeters in production service, another 165 meters in this service; still another, 100 volumeters in terminals. The trend is certainly toward a larger use of volumeters in all kinds of petroleum measurement with the possible exception of the refinery. Here the need is for rate meters more than for quantity meters and for this reason the inferential meter will not be displaced soon in the refinery. The general practice is to use each volumeter for measuring only one product. However, volumeters are demonstrating their usefulness and economic advantage in products pipe lines where several products of considerable difference in viscosity must be measured during the course of normal operations. One of the uses for volumeters is in the measurement of salt-water production.

Regular Maintenance Schedule

Question 4, "Do you have a regular maintenance and calibration schedule for meters," revealed that the vast majority of volumeter users do have such a maintenance and calibration schedule. Most users check their meters for accuracy at regular intervals and on the basis of these checks determine the necessity for repairs or service to the meters. Some users check their meters every 15 days, others every 30 days; still others have a 2 or 3 months' schedule. The life of a volumeter depends on several factors, and these factors vary with the different uses of meters. Most all users agree that a regular schedule for calibration and maintenance is desirable and that it must be set up on the basis of each user's experience.

The accuracy of measurement expected or required of volumeters (Question 5) has been, and continues to be, a subject of much discussion. The absolute accuracy obtained in meter measurement depends primarily upon the careful calibration of the meter. If the volume of the proving tank is known or can be read only to 0.5 per cent, or 0.25 per cent, the basic accuracy of a meter cannot be any closer even with the most careful calibration procedure. Similarly if the meter register can be read only to 0.5 or 0.25 per cent of the volume of the prover tank, then the meter measurement can be no closer even with an entirely accurate prover. Errors in both prover tank and meter register reading may be cumulative or may cancel one another. Many users require and expect measurement within ±0.1 per cent. This is closer than that required by any other kind of commercial measurement, such as measurement of pressure, temperature, etc. Where volumeters are used to measure gasoline in the service station, sealers permit errors of only ±7 cu. in. in 5 gal., or about ±0.6 per cent; on resealing, one-half this error, or about ±0.3 per cent. This requirement is easily met by the 1-in. volumeter, which, with regular maintenance and calibration, can be expected to measure over an 8 years' life with maximum error of less than 0.3 per cent. Here these small meters are measuring only one product in a narrow range of flow rates.

Larger Meter Requirements

The requirements for larger meters which are used to measure liquids at varying viscosities and temperatures must be based on whether or not each meter is calibrated at the viscosity and near the temperature at which the meter is operated. One large user of volumeters in product-pipe-line service reports that he has found it desirable to calibrate each meter on each product as it is passing through the meter. This user reports that differences of 0.1 and 0.2 per cent have been found in meter calibration between one grade of gasoline and another in the pipe line. By careful control, this volumeter user expects and undoubtedly secures meter measurement with not more than 0.1 to 0.2 per cent error. Where account is not taken of variation of meter calibration caused by viscosity differences and temperature differences, it is doubtful whether errors of less than 0.4 or 0.5 per cent should be expected, especially when meters for measuring gasoline and other hydrocarbons of less than 1 centipoise viscosity are calibrated on some other more viscous liquid. Meters which are used at fairly constant flow rates on one product within a reasonably close temperature range, and are carefully calibrated and maintained, should be expected to measure within 0.25 per cent error. This figure is about the average of the required accuracy by the companies reporting their experience to the committee.

The ability of meters to check over extended periods of operation (Question 6) is reported to be extremely close by a surprisingly large number of users. Some reported that volumeter measurement checkd out somewhat closer than the accuracy required of the individual meters. The general average was 0.2 per cent with some reporting a check out to 0.1 per cent.

In answer to the question regarding kind of calibrating equipment used, nearly all volumeter users reported the use of volumetric tanks of some kind or other. This would be the obvious answer because of the ready availability and ease of use of this type of equipment. Weigh-type calibrating equipment, because of its bulk and the calculations involved in changing weights to volumes, would be of little practical value other than in the laboratory. The types of volumetric tanks reported varied from small proving tanks to large gage tanks. Two large users of meters reported the successful use of master calibrated meters for comparison with the field meters. This method of field calibration is that advocated by one company which has done considerable laboratory research work on volumeters. Many of the volumetric tanks are open to the atmosphere. Open tanks are of course satisfactory where there is no chance of the liquid on which the meter is being calibrated evolving gas after the liquid has entered the proving tank. If there is evolu-

E. E. AMBROSIUS

E. W. JACOBSON

Coauthors of this paper have been long engaged in research work. Mr. Jacobson is engineer in charge of the design section of Gulf Research & Development Co. Since joining Gulf in 1933 he has been successively engineer in charge of research and testing of service-station gasoline pumps, compressors and truck meters and engineer in special design engaged in development of lubricant and fuel-oil testing equipment.

Professor Ambrosius, University of Kansas, taught at the University of Illinois in the department of mechanical engineering for 8 years. Since graduation from the University of Illinois in 1928, where he received a master's degree in 1931, he has been active in various types of research work and has received two research awards for his work.

Paper presented before Division of Production at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

*Head of department of mechanical engineering, University of Kansas, Lawrence, Kans. Member, subcommittee for joint A.S.M.E.-A.P.I. volumeter research.

†Design engineer, Gulf Research & Development Co., Pittsburgh, Pa. Secretary, subcommittee for joint A.S.M.E.-A.P.I. volumeter research.

tion of gas or evaporation of the liquid in the proving tank, there certainly cannot be an accurate check on the meter performance. Several reported the use of closed volumetric tanks for use with gasoline and other volatile liquids. This of course applies to meters other than those used in the sale of gasoline in service stations and from bulk-plant distributing trucks. State and local sealers are mainly interested in how much the customer receives. The sealers and oil companies alike, for the most part, have been content to calibrate the service station and distributing truck meters by use of open seraphin-top proving tanks. It takes only a simple experiment by pouring gasoline from one 5-gal seraphin sealer's measure into another to determine the significant magnitude of evaporation between dispensing hose and the test measure. This loss will depend upon the ambient temperature and vapor pressure of the gasoline. No credit is given the meter for this evaporation loss. In meters for the sale of butane, propane, etc., use of the closed proving tank is the only possible means of calibrating, whether it is of the volumetric or weigh type.

Open and Closed Tanks

Question 8 deals with the use of open and closed volumetric tanks with crude, gasoline, and lighter ends. Open volumetric tanks are used for the most part in proving meters on crude oil while some users have found it desirable to employ a closed volumetric tank prover under line pressure where the vapor pressure of the crude being handled is such that evaporation would be a factor. In proving meters on gasoline, most of the provers are in the hands of sealers, who, as stated in the previous paragraph, are not concerned with evaporation loss, therefore find the open-top volumetric tank satisfactory. In product-pipe-line service, one large user of volumeters finds it necessary not only to use a closed system for gasoline but also to use either water displacement or to saturate the atmosphere over the gasoline to reduce evaporation due to agitation of the liquid in the prover system. The trend is most certainly toward use of closed proving tanks where close meter measurement is desired and there is any possibility of evaporation or evolution of gas from the liquid in the meter and prover system.

The question regarding the best pressure to be maintained in the closed prover seems best answered by two large users who maintain as nearly as possible the same pressure in the prover as that maintained on the meter during use. Where this is not possible, the pressure is maintained on the prover tank as near to that on the meter as the prover tank will stand. One user states that he maintains 125-lb. pressure (probably a pressure near the meter-operating pressure although not so stated). Several maintain only nominal pressure slightly above atmospheric. The effect of pressure on meter-measuring characteristics has been much discussed. The easiest solution seems to be to calibrate at or near the pressure at which the meter operates.

The best and most widely used design of volumetric proving tank is an upright cylindrical tank with coned top and bottom sections; with a seraphin neck at the top and bottom, each equipped with suitable sight gages. The minimum volume of the tank should be the amount the meter will pass in 1 minute at full rate of flow; the maximum need not be more than the amount the meter will pass in 5 minutes at full rate of flow. The design of the seraphin neck should be such that the amount in the tank can be determined within 0.1 or 0.2 per cent or as desired. The length of scale on the seraphin neck should be enough to indicate the amount to ±1 per cent of the tank volume. The reason for the coned top and bottom sections is to assist in eliminating gas bubbles and pockets from the tank. Suitable filling and drain connections need to be provided, of such size and shape as to reduce turbulence and violent agitation in the fluid which might cause evolution of gas or vapor from the liquid. Of utmost importance also is the provision for suitable means for determination of the starting level in the tank. A seraphin neck on the bottom of the tank, equipped with sight gage, will provide excellent determination of the starting level. The bottom seraphin neck need not be as long as the top neck. The construction should be sturdy to stand internal pressures encountered in testing without distortion. All pipe connections should be carefully made to avoid straining the tank in any way from thermal expansion or pipe-line stresses. Covering the inside with a suitable corrosion resistant coating will aid in insuring long life of the tank.

Provers Considered Accurate

In answer to Question 11, most users of volumetric provers believe their provers to be accurate within 0.1 per cent for small provers and 0.2 to 0.3 for the larger provers. The absolute accuracy will depend upon the accuracy of the primary standard of measurement. As a primary standard, the sealer's 5-gal. seraphin measure is almost universally used. This primary standard must be handled very carefully and be stored in a rugged protecting case to prevent dents or its calibration cannot be trusted. It is best practice to have at least three sealer's measures which can be checked against one another frequently.

Nearly everyone uses water at nearly constant temperature, bucketing it into or out of the prover by means of the 5-gal. sealer's measure. At least three "bucketings" are required to check before the calibration is set. In calibrating large tanks, some employ a 1-in. positive displacement meter which is calibrated with a 5-gal. sealer's measure just before and immediately after filling the prover. The liquid used in the operation is that which will be used in proving large meters. Several methods are used to eliminate errors due to wetting the test measure. One method is to dry the test measure after each filling and emptying. Another is to drain the test measure each time for a definite length of time as determined by stop watch. In most cases the proving tank is wet with the calibrating liquid during filling and emptying. No general method for accounting for variation of wetting the tank walls is in use.

Design of Provers Important

Most replies to Question 14, regarding change in prover calibration with time, due to rust accumulation or other cause, indicated cognizance of the need of good prover design to resist deformation of the shape of the tank and to resist corrosion. The common opinion is that the calibration of the prover tank should not change if carefully designed and handled. It is also common opinion that the calibration of the prover tank should be checked at reasonably frequent intervals depending upon the frequency of use and tendency of the test fluid to corrode the tank. If a prover tank is unused for considerable time, it should be coated inside with some sort of rust preventive.

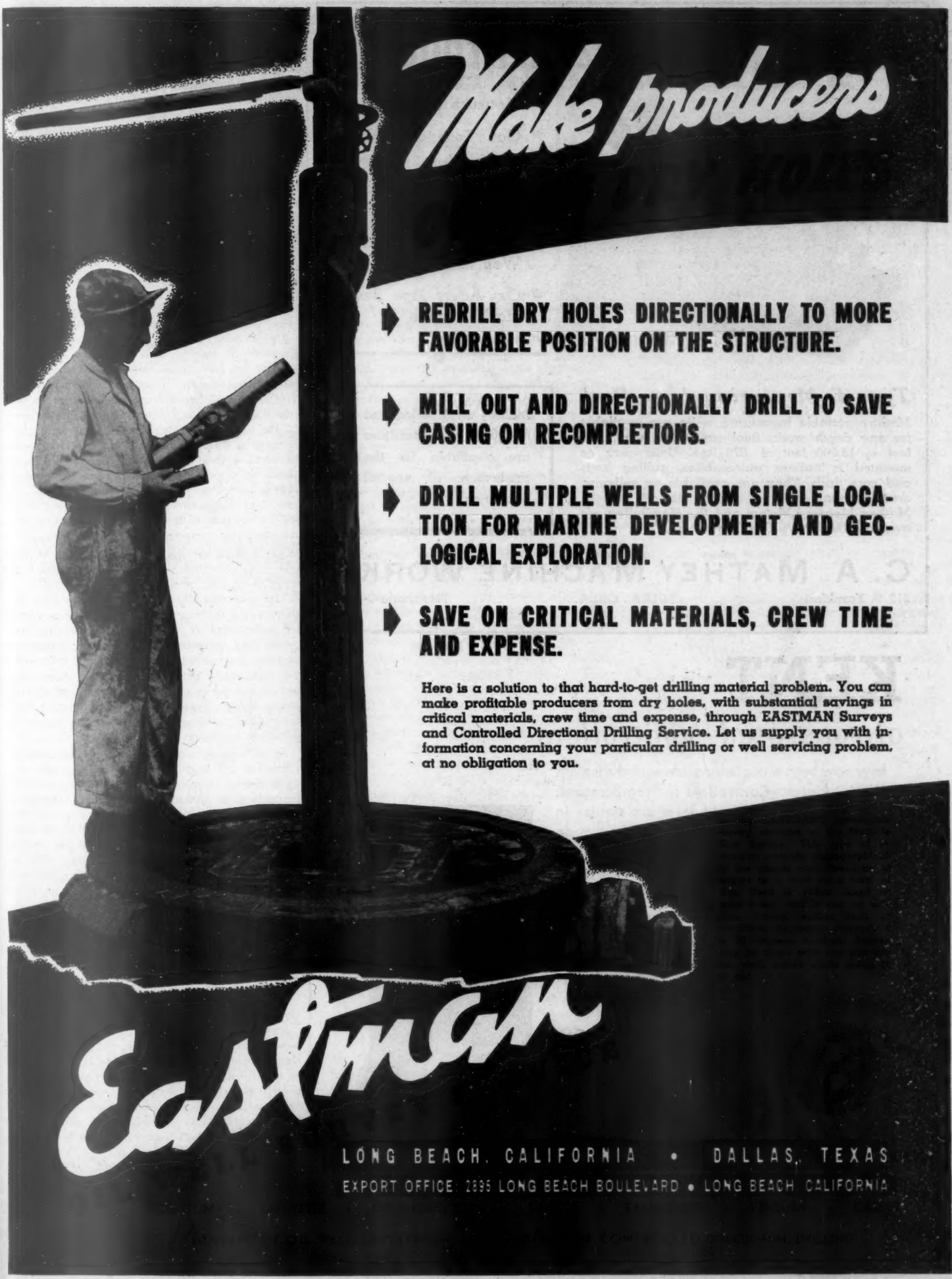
In calibrating meters, nearly everyone uses the standing start method of test. Only one or two use the running start method; where the length of test is long enough (6 to 24 hours) so that errors due to inaccuracies in readings at both beginning and end of the test are made insignificant. The biggest difficulty in the running start method is determination of the exact readings of both meter and prover at beginning and end of the test. The running start and stop method was used during the committee's test program on oils at University of Oklahoma. Here special apparatus was developed so that the meter readings were taken photographically in synchronism with the motion of the test controls. This method proved quite successful. In the tests at the Naval Experiment Station on gasoline, the standing-start-and-stop method was used. The important thing to watch in the standing-start-and-stop method of testing is that the fluid stream is controlled so that smooth acceleration at the start and smooth deceleration at the end of the test is achieved. The test controls should be of such design that the operator can closely adjust the flow of fluid. If the controls are opened too rapidly it is quite possible for the pressure in certain parts of the system to fall below the vapor pressure of the test fluid so that quantities of gas are evolved during the acceleration of the fluid stream. If the controls are closed too rapidly at the end of the run, hydraulic shock may result, which in some designs may stretch the proving tank, throwing it off calibration. Too rapid closing may also cause the metering element to drift due to inertia of the moving parts, which would alter the meter reading from the true reading. The volumeter committee had a series of tests made recently to determine the effect of start-and-stop proving. These tests were made on the volumetric water-displacement-type prover at the Naval Experiment Station. They showed that with reasonable care in controlling the fluid rate so that shock, depression of pressure, and evolution of gas were eliminated, no significant error was involved in use of the start-and-stop method.

Factors in Calibration

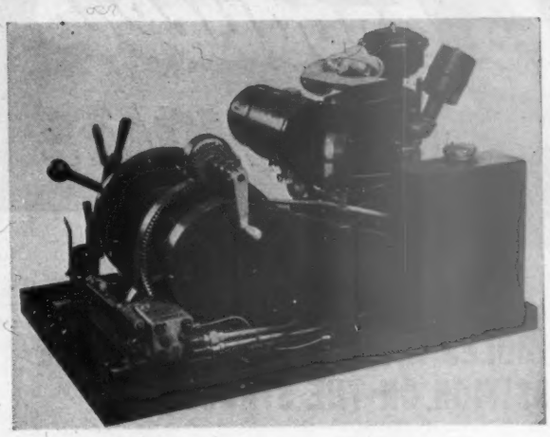
The flow rates at which each meter should be calibrated depends upon several factors. If the meter is new, the nature of the meter's characteristic curve should be determined before it is put into service. This would require calibration at 8 to 10 flow rates, starting from 10 per cent up to 100 per cent of rated capacity. Experience on the Norman tests indicates that most meters have a wearing-in period when they are first put into service during which the measuring characteristic curve is somewhat unstable. For this reason a second complete calibration should be made after a short period of operation. The characteristic curve of a meter cannot be determined with certainty with only two or three flow-rate points on the curve. The Norman tests show some meters may have a short range of flow rates at which the error curve does not follow a smooth line. This may be caused by conditions of inertia, internal friction, trapping etc., dependent upon the design of the meter. Of two meters of similar size, design, and make, one may have a smooth error curve and the other exhibit this peculiar characteristic. This variation may occur at the exact rate at which the meter is to be operated, so a new meter should always be given a complete test.

When the nature of the complete error is known for a meter, calibration at one or two points near the operating rate of the meter should be sufficient over the period between maintenance inspections. It has been the experience of several users who have life test data that volumeter characteristic curves drift with use. For some meters the entire curve shifts practically uniformly as the meters wear. For others only the portions in the lower 35 per cent of flow rates shift appreciably. By observation of the nature and extent of the shift in the characteristic curve for any meter, its condition and maintenance needs can be determined. For this reason it will be found desirable to determine the complete error curve at intervals dictated by the maintenance schedule.

Replies to Question 18 indicate that most users calibrate their meters on the liquid to be measured. The Norman tests indicate that this practice must be followed if precise measurement is to be obtained. These tests show that errors of


Make producers
REDRILL DRY HOLES DIRECTIONALLY TO MORE FAVORABLE POSITION ON THE STRUCTURE.
MILL OUT AND DIRECTIONALLY DRILL TO SAVE CASING ON RECOMPLETIONS.
DRILL MULTIPLE WELLS FROM SINGLE LOCATION FOR MARINE DEVELOPMENT AND GEOLOGICAL EXPLORATION.
SAVE ON CRITICAL MATERIALS, CREW TIME AND EXPENSE.
Here is a solution to that hard-to-get drilling material problem. You can make profitable producers from dry holes, with substantial savings in critical materials, crew time and expense, through EASTMAN Surveys and Controlled Directional Drilling Service. Let us supply you with information concerning your particular drilling or well servicing problem, at no obligation to you.
Eastman
LONG BEACH, CALIFORNIA • DALLAS, TEXAS
EXPORT OFFICE: 2895 LONG BEACH BOULEVARD • LONG BEACH, CALIFORNIA

Mathey Specialized Products



- Measure Meters
- Gas Testing Equipment
- Portable Well Measuring Units
- Reeling Equipment for Well Shooting
- Oxy-Acety Pipe Beveling Machines

Type E Measuring Line Reel

Mathey portable measuring units are available for any depth work. Reel capacities from 5,000 feet to 15,000 feet of .072 line. Units may be mounted in trailers, automobiles, pulling units and core drills. They are available as self-powered gasoline units or power take-off models. Mathey Measure Meters and the Hay-Pulley are available for use with all reels.

Mathey engineering and machine shop facilities are available for the production of special equipment.

C. A. MATHEY MACHINE WORKS

212 S. Frankfort **TULSA, OKLA.** **Telephone 3-3623**

KENT

air-operated controllers

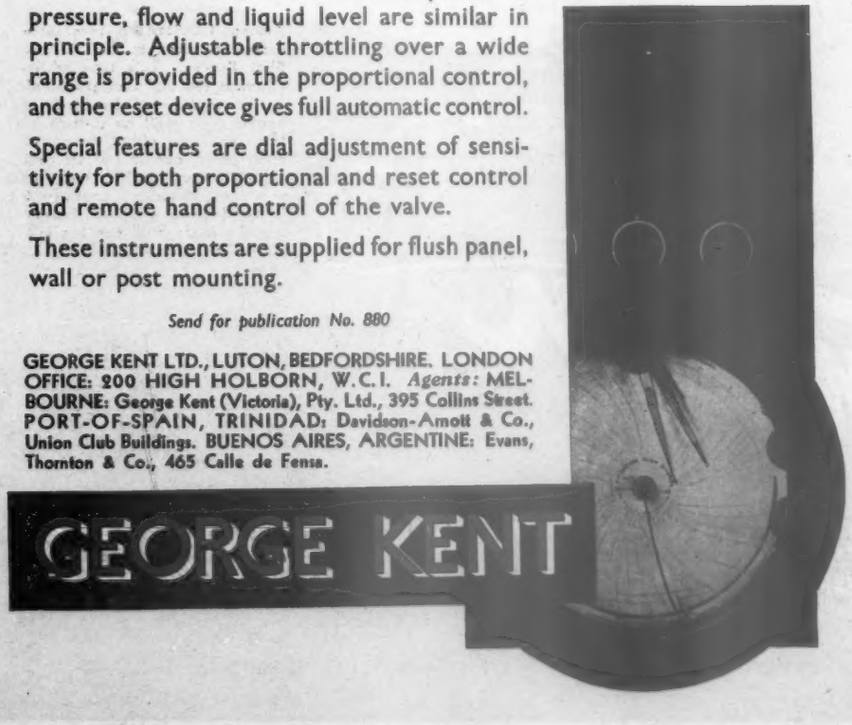
have now been brought into line with the famous "KM" Meter. Controllers for temperature, pressure, flow and liquid level are similar in principle. Adjustable throttling over a wide range is provided in the proportional control, and the reset device gives full automatic control.

Special features are dial adjustment of sensitivity for both proportional and reset control and remote hand control of the valve.

These instruments are supplied for flush panel, wall or post mounting.

Send for publication No. 880

GEORGE KENT LTD., LUTON, BEDFORDSHIRE. LONDON OFFICE: 200 HIGH HOLBORN, W.C.I. *Agents:* MELBOURNE: George Kent (Victoria), Pty. Ltd., 395 Collins Street. PORT-OF-SPAIN, TRINIDAD: Davidson-Arnott & Co., Union Club Buildings. BUENOS AIRES, ARGENTINE: Evans, Thornton & Co., 465 Calle de Fensa.



considerable magnitude (0.3 to 0.5 per cent) may be present if each meter is not calibrated on liquid very near the viscosity of the liquid to be metered. Effects of viscosity on the shape and position of the meter error curve for most meters are very pronounced at rates of flow below 15 per cent of rated capacity and above 85 per cent to a lesser extent. The importance of calibrating meters on liquids of the same viscosity as those to be measured increases as the viscosity of the measured liquids decreases below 1 centipoise. More information on the effects of viscosity will be available in a paper covering the preliminary study of the Norman and Annapolis tests to be presented at the annual A.S.M.E. meeting in December in New York.

Temperature Corrections Necessary

The need for making corrections of meter readings for difference in temperature in the metered liquid is recognized by most users because of the large thermal coefficient of expansion of liquid hydrocarbons. The Norman tests indicate that temperature changes also affect the shape and location of the meter calibration curve, even more than viscosity changes for some meters. The effects of temperature on inherent calibration are not uniform from meter to meter, even of the same design and make. Corrections for changes in fluid volume can be made from tables based on thermal expansion of the metered liquid. However, the only way errors from temperature-change effect on internal meter clearances, friction, and displacement can be minimized is for the meter to be calibrated at a temperature near its operating temperature. This appears to be fully as important as calibrating the meter on a liquid of the same viscosity as the liquid to be metered if precise measurement is desired.

The compressibility of liquid hydrocarbons at pressures and temperatures now being measured by volumeters is insufficient to require compressibility corrections. If the meter housing is of sufficient strength to prevent distortion with the pressure to be encountered in service, there should not be any need for correction for this cause either. Some users are calibrating their meters near the operating pressure so as to eliminate distortion errors.

In calibrating meters measuring volatile liquids (Question 21) best practice is to eliminate possible errors from evaporation. There are two methods now in use. One is to have the liquid entering the proving tank displace water; the other is to have the liquid entering the proving tank displace presaturated natural gas. Water displacement eliminates all possibility of evaporation but is only useful on gasolines, and certain light fractions which do not form an emulsion with water. When the presaturated gas displacement method is used, there may be some evaporation if violent agitation is present so that supersaturation may occur. When using the gas displacement method the calibrating liquid should enter the bottom of the prover tank.

Volumeters for measuring liquid hydrocarbons are by the nature of their use, precision instruments and must be treated as such. They are mechanical in nature and depend on careful design, proper installation and intelligent handling in use to operate with characteristics necessary to give the close measurement required. As the precision of measurement increases, so does the cost of calibration, operation and maintenance. A fair balance of all factors involved is required.

Acknowledgment

This paper is presented as a part of the program for volumeter research being carried on jointly by the A.S.M.E. and A.P.I. The authors wish to acknowledge and thank the many contributors of information on volumeter practice which has made this paper possible.

Hydration-Pressure Relations In Clays and Heaving Shale

By H. H. POWER*, BARNABY L. TOWLE†, and JOSEPH B. PLAZA‡

A. P. I.

Some shales are thought to heave into the bore hole of drilling wells because of the inclusion of varying quantities of clay materials which swell and expand when wetted by water from the drilling mud. The expanded shale not only fills the hole a large distance above the point of entry, but in some cases also exerts sufficient pressure to crush the steel casing.

A survey of the literature indicates that little has been written concerning the swelling of clay minerals. Most of the literature on swelling is confined to descriptions of experiments performed with the so-called elastic gels. Hence, opportunity exists for research in this field, with due regard for the accomplishments to date in allied investigations.

Accordingly, an investigative program was initiated in the petroleum engineering laboratories of the University of Texas in order to determine the hydration-pressure relationships existing in clay materials, such as Wyoming bentonite, when wetted with water. The conclusions drawn from this work indicate that certain clay materials are capable of producing pressures of considerable magnitude when confined during hydration. The effects of certain chemicals on pressure increases or decreases also are shown. It is also apparent that the nature of the exchangeable bases present may influence the swelling-pressure characteristics of the clay material.

The need for additional research is indicated preliminary to corrective chemical treatment of "heaving shales" encountered in drilling operations.

Paper presented before Division of Production at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

SOME shales are thought to heave into the bore hole of drilling wells because of the inclusion of varying quantities of clay materials which swell and expand when wetted by water from the drilling mud. Increases in the apparent volume of the material up to 900 per cent have been recorded.[1] The expanded shale not only fills the hole a large distance above the point of entry, but also in some cases exerts sufficient pressure to crush the steel casing.[2]

A survey of the literature indicates that little has been written concerning the swelling of clay minerals. Most of the literature on swelling is confined to descriptions of experiments performed with the so-called elastic gels. Hence, opportunity exists for research in this field with due regard for the accomplishments to date in allied investigations.

Whenever a dry gel takes up water, the system of gel and water together at first occupies less volume than the water plus the dry gel separately.[3] This contraction is greatest during absorption of the first small amounts of liquid. The dry gel, however, undergoes a marked increase in volume on hydrating, and the pressure thus created can attain the order of several hundred atmospheres.[4,5,6,7]

Swelling, therefore, can be distinguished by two factors: a volume increase and change of pressure. Concerning the influence of pressure on the process of swelling, Kruyt and Van Klooster[8] made the following observations (italics are those of the present authors):

"If gel and liquids are compressed *together*, an increase in pressure, according to the theorem of Van't Hoff-LeChatelier, will favor the process that involves a decrease in volume; hence, *uniform* pressure increases swelling. In general, however, we study something different; the pressure of the swelling gel is measured in such a way that the mobility of the water is maintained. We are then dealing with a nonuniform pressure, and, since the gel swells with increase of volume, this one-sided pressure will hinder the process of swelling.

"The latter is, indeed, an equilibrium process in the sense that by exerting a nonuniform pressure on the swelling gel we can prevent further swelling. If the pressure applied is lower than the pressure of swelling under the given conditions, the swelling proceeds until both pressures are equal. If, on the other hand, the pressure exerted exceeds the pressure of swelling, water is squeezed out of the gel until the pressures are again the same.

"It thus becomes apparent that *small amounts of imbibed liquid correspond to large pressures of swelling, and, conversely, that large quantities are taken up under small pressures of swelling.*"

Posnjak[9,10] studied the relationship expressed above and placed a gel sample in a porous cup, and enclosed cup and sample in a tube, filling the space above the gel with mercury. He connected a glass capillary between the tube and a cylinder of compressed gas, thereby providing for observation of the displacement of the mercury meniscus. Setting the porous cup in a beaker of water so as to obtain hydration of the gel, he balanced its swelling pressure by halting the moving meniscus with gas pressure from the cylinder. Accordingly, he obtained a measure of the volume of imbibed water necessary to create such a pressure. The curves of his results illustrate clearly the principle that the amount of liquid decreases with increasing pressures.

Many theories have been proposed to explain the mechanism of swelling. In their article on anomalous osmosis, Bartell and Sims[10] have listed seven theories, all presented in the literature before 1922. Space does not permit discussion of the various theories propounded, but interested readers are directed to the theory of Proctor and Wilson, which is considered to be important as a contribution to a quantitative interpretation of the phenomena of swelling.[11,12] Northrop and Kunitz[13] have offered an explanation for the swelling of isoelectric gelation in water.

The effect of electrolytes on swelling has been the subject of investigations for more than 50 years. Hofmeister[14] showed that the swelling of protein gels was a minimum at the isoelectric point. Loeb[15] attributed swelling differences to the influence of pH. Actually, swelling is not influenced by pH alone.[16] Some salts increase and some decrease the swelling tendency of gelatin; salts cut down the swelling caused by acids and alkalis.[17]

Katz[18] and Freundlich[19] have analyzed the relations existing in gels between swelling pressure, heat of swelling, relative vapor pressure, and volume contraction. Terzaghi[20] pointed out that the equation for osmotic pressure and Katz' equation were identical, a fact which suggested to him the analogy between liquids and gels and led him to propose the following expression for swelling:

$$-\frac{RT}{MV_0}\ln h = P' + P''$$

Where:

P' = swelling pressure caused by the tension in the liquid created by the surface tension at the system's liquid-solid-gas boundary

P'' = an internal energy reflecting the molecular change in the liquid caused by absorption

The left-hand side of the equation is the formula for osmotic pressure. For true solution, P' becomes equal to zero, as no voids are present to produce capillary phenomena. P'' represents the osmotic pressure entirely. On the other hand, for two-phase systems, the coarser the solid material with consequent increase in pore size or voids, the more predominant the role of P'. The latter represents a mechanical pressure of swelling due to tension in the system. According to Terzaghi the empirically derived formula of Freundlich and Posnjak is really an expression for P'.

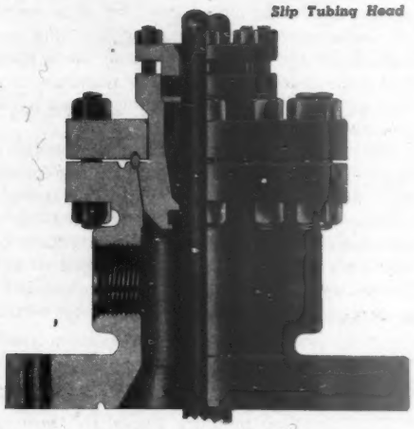
The foregoing discussion has dealt solely with the phenomenon of swelling of gels, inasmuch as much less is known about swelling of clay minerals. Terzaghi[21] states that the laws of swelling apply to clays as well as to gels. However, the generally accepted explanation of the swelling mechanism in clays has been presented by Hofmann,[22] Bradley,[23] and others on the basis of the expanding lattice structure.

Posnjak[24] permitted a gel sample to hydrate, and then measured the pressure necessary to prevent further hydration. He has shown that the more liquid a gel imbibes, the less is the pressure necessary to keep it from imbibing more. The relationship between his swelling curves and the performance of samples in the bomb is thought to be somewhat as represented in Fig. 1. As water enters the sample, the pressure in the system increases spontaneously along the line *OB*, which represents any of the curves of Fig. 2. This simple straight-line relationship between pressure and water imbibed exists due to the fact that the air originally in the sample is compressed isothermally by the encroaching water. When the pressure and water content reach a certain equilibrium value represented by the point *B*,

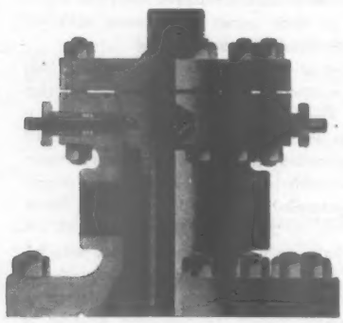
*Professor of petroleum engineering, University of Texas, Austin, Tex.
†Shell research fellow, University of Texas, Austin, Tex.
‡Graduate student, University of Texas, Austin, Tex.

HEADQUARTERS FOR *Safer* WELL HEADS

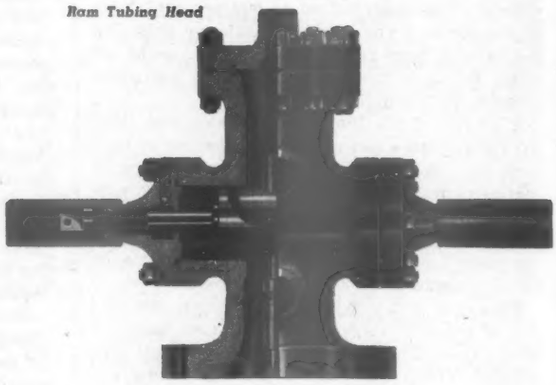
Slip Tubing Head



Mandrel Tubing Head

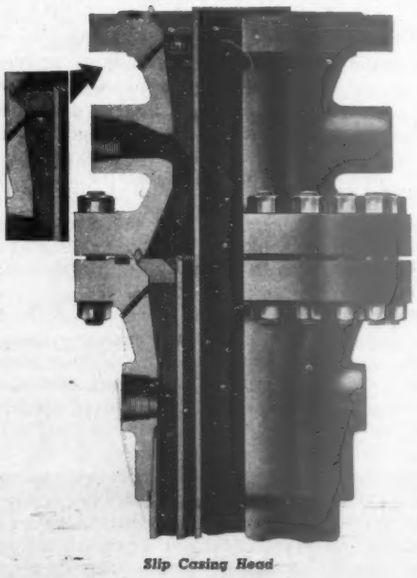


Ram Tubing Head



Rector Well Equipment Company's more than 12 years of designing, developing and manufacturing surface control equipment exclusively has resulted in a *safer casing and tubing head* to match your drilling, completion and production problem . . . whatever it may be. The reputation of RECTORHEADS is backed by thousands of safe, dependable, leak-proof well hook-ups in service around the world.

Three distinct types of Rector Casing Heads and Rector Tubing Heads pictured here are a few of the many approved RECTORHEAD designs. Full details covering these and other RECTORHEAD designs are in your Composite Catalog, your Drilling Equipment Directory, or your Rector Catalog. Many of these designs are still available from supply store and warehouse stocks in all sizes and pressures.



Slip Casing Head

RECTORHEAD

SUCCESSOR TO THE BRADENHEAD

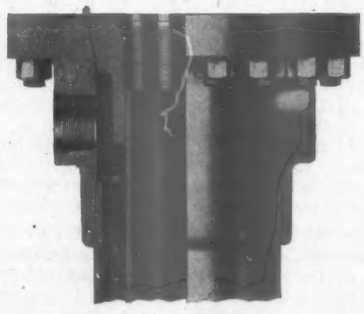
RECTOR WELL EQUIPMENT CO., INC.

Ft. Worth, Texas

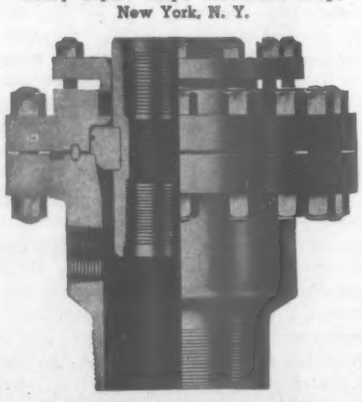
Representatives in All Active Areas

Export Office:

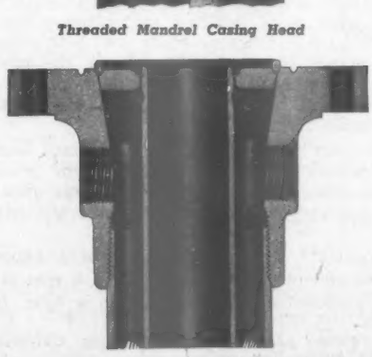
Lucey Export Corp., Woolworth Bldg., New York, N. Y.



Threaded Mandrel Casing Head



Split Ring—Recessed Coupling Casing Head



Welded Mandrel Casing Head

this point of apparent "maximum" swelling pressure of the sample corresponds to the particular water content that causes the swelling up to that point. Posnjak's type of curve, therefore, is the locus of equilibrium-pressure points for different water contents.

If a smaller sample, or one having less air

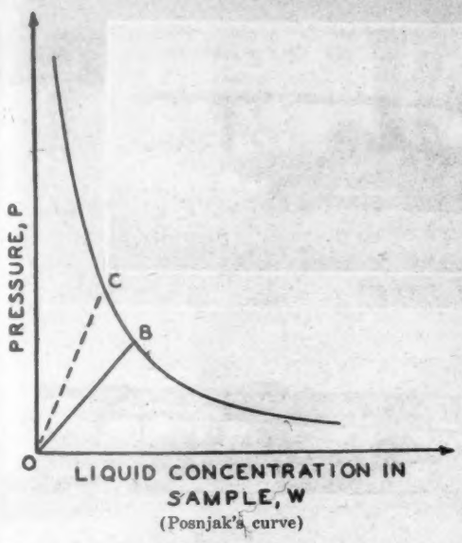


Fig. 1—Comparison of hydration-pressure curves

space (lower per cent porosity) than the sample whose performance is represented by line *OB*, were to hydrate in the bomb, less water would be required to fill this space. Hence, the ratio of pressure to water increment would be higher, causing the line *OB* to steepen and intersect Posnjak's curve at a higher equilibrium pressure, so that some line such as *OC* would become the path for the hydrating sample. In other words, the constant *K'* in the equation for line *OB* would become large, producing equilibrium at a lower water content and a higher pressure.

The mechanism of water absorption by montmorillonite is in dispute. The only essential difference between the nonswelling and the swelling varieties seems to exist in the nature of the exchangeable bases present. It is known that the hydrating power of ions having a given charge is inversely related to their size.[26] Thus, certain bases should produce greater swelling than others having the same charge, because the former can attract and hold more water. According to Sullivan[26] the attraction between anions and cations is related to the size of the ion. For instance, for ions of equal charge a small ion such as lithium is attracted by a greater force than a larger ion such as potassium. In base exchange, however, the hydration of the ions must be considered. Accordingly, the smaller lithium ion will attract more water than the larger potassium ion. As a result, the hydrated lithium ion is larger than the hydrated potassium ion. The following series lists the *hydrated* ions in the order of their size: lithium, sodium, potassium, rubudium, and caesium.

Hauser[27] states that the thickness of the water films encountered in clay systems cannot be accounted for by the hydration of counterions. It is thought that the separation of the particles is due to a balance and interaction of Coulombic forces between charges on the surface of the particles and the surrounding ions. The distance separating the particles would depend upon concentration, size and shape of particles, the net surface charge, and the nature and number of the counterions.

The research program conducted by the authors at the University of Texas in the Bureau of Engineering Research during the past year had for its purpose the development of an apparatus and technique for studying hydration-pressure phenomena of bentonitic and other clay materials, including heaving shale. It was thought that a direct attack on the rate of pressure increases would constitute an important addition to the studies previously made on bentonitic suspensions.[28]

The apparatus finally adopted for this investigation has been described previously.[29] It consists essentially of a cylinder made from one piece of cold-rolled shafting, so bored as to provide a shoulder for the support of a perforated disk and blotting paper. One end of the pressure chamber is closed by a heavy steel plug, in the top of which two seats are provided for the attachment of steel tubing. Accordingly, the cylinder may be used in connection with a mercury injector as well as a pressure gage. The end of the cylinder opposite the plug is closed by a steel disk, and perforated. The reagent chamber is located below the shoulder supporting the base plate. The end of the reagent chamber opposite the base plate is closed by a rubber stopper. A burette is connected to this chamber so that the amount of liquid withdrawn by the sample can be measured.

Preparing and Loading the Apparatus

Wyoming bentonite containing approximately 90 per cent montmorillonite[30] was used for preliminary testing in the apparatus described. After having placed the base plate on the shoulder in the pressure chamber, a porous stone disk was placed on the base plate, but it was found that the stone cracked during the compression of the sample. Wire screen was substituted for the stone disk to eliminate this difficulty, and a piece of blotting paper was placed on top of the screen and smoothed down to a tight fit. The air-dried powder then was weighed out and tamped into the cylinder, a portion at a time. The piston was inserted, and the cylinder centered on the platform of the mechanical press. The pressure quickly was brought up to the desired value, due care having been exercised to prevent consolidation of the sample. At the end of 5 minutes the pressure was released, and the amount of the sample squeezed by the piston during compression subtracted from the sample weight.

Inasmuch as it was desired to examine the test material in a state of compaction that would correspond to that existing at subsurface depths, a series of tests was made to determine the relationship between the pressure used to compact the sample and the density of the resultant material. Over the range of pressures investigated, the straight-line relationship shown in Fig 3 was obtained. The density of air-dried lumps of the material in its natural state was found to be 2.13 g. per ml. After the curve of Fig. 3 had been prepared, additional samples were compacted at 12,550 lb. per sq. in., which corresponded to the foregoing density on the curve. The average density of these samples was 2.11 g. per ml. None differed from the average more than two units in the second decimal place. This average value is surprisingly close to the value predicted by the curve. The density of all samples in subsequent tests was checked by measuring the thickness after compaction and comparing it with that of the samples on which the density was determined.

After the piston had been removed, the pres-

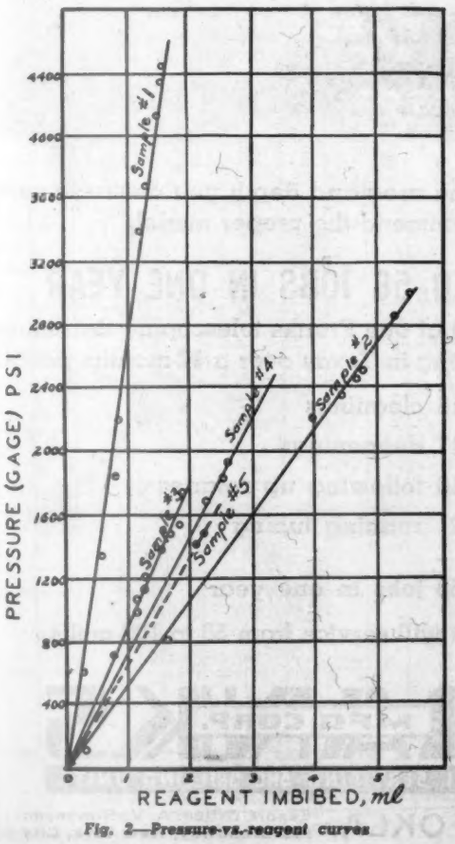


Fig. 2—Pressure-vs.-reagent curves

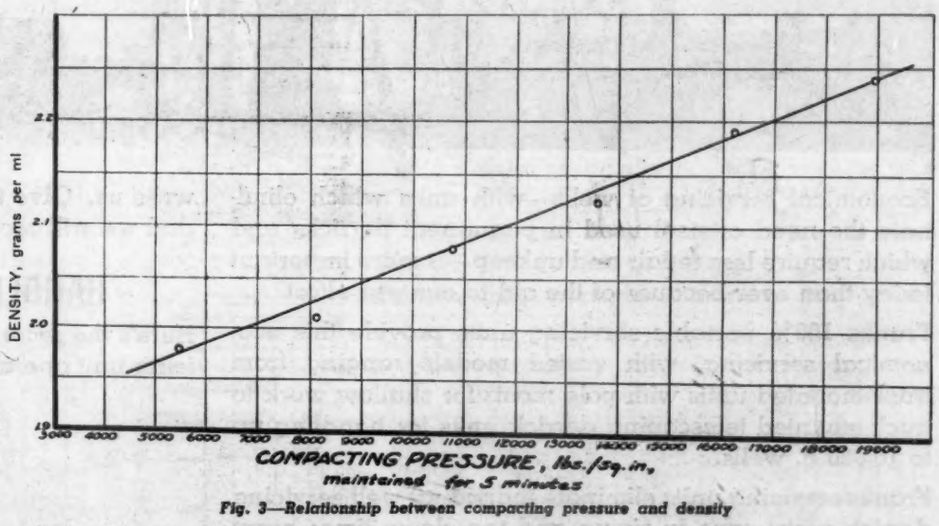


Fig. 3—Relationship between compacting pressure and density

Over 500 Tons of Steel *Saved* By Each Telescoping Servicing Unit

FRANKS MFG. CORP.
WELL SERVICING AND DRILLING UNITS

Economical servicing of wells—with units which eliminate the need of steel used in permanent derricks and which require less repair and upkeep—is more important today than ever because of the aid to our war effort.

Franks 100% portable servicing units provide this economical servicing, with varied models ranging from truck-mounted units with pole masts for shallow work to truck-mounted telescoping derrick units for handling up to 10,000 ft. wells.

Franks servicing units eliminate individual well servicing derrick costs; save in rig-up and tear-down time; carry their lines and blocks strung in moving; and have facilities for easily raising and lowering derrick.

For further information see the Composite Catalog or write us. Give the area and depth you desire to service and we will recommend the proper model.

HANDLED 58 JOBS IN ONE YEAR

Here's the record of one Franks telescoping derrick servicing unit operating in Texas over a 12-months period:

16 cleanouts
11 deepenings
10 following up rotaries
21 running tubing
—
58 jobs in one year

Each Franks unit will service from 50 to 100 wells.

EACH FRANKS SERVICING UNIT NOW IN USE SAVING TONS OF STEEL FOR WAR USE

A recent survey of Franks units in the field show that each unit is averaging a saving of over 500 tons of steel in the California area by eliminating the need of permanent derricks.

FRANKS MFG. CORP.
WELL SERVICING AND DRILLING UNITS

TULSA, OKLA. Export Office: A. V. Simonson 149 Broadway, New York, City

sure cylinder above the sample was filled with mercury and rocked to remove all air bubbles from the chamber. Mercury was added until the level surface stood at or slightly above the ferrule seat in the gage connection. The bomb then was placed on its side in a suitable cradle, with the gage connection pointing upwards, and the entire assembly transferred to a constant-temperature cabinet. Temperature control to a fraction of a degree was found to be necessary, because changes of approximately 100 lb. per sq. in. were noted where the temperature of exposed gage and connections were not controlled, together with the temperature of the bomb itself.

The reagent chamber was prepared by placing one-holed rubber stoppers in the two holes. The tip of a burette was thrust through the smaller stopper, and the larger one was connected to a vacuum pump.

Preparation of Samples

1. *Dispersion of the material.*—By adding the proper amount of dry "Volclay" to distilled water agitated with a mechanical stirrer, a suspension containing 4 per cent by weight of solids was produced. The suspension was stirred 2 hours a day for a period of 2 weeks in order to obtain complete dispersion and hydration.

2. *Electrodialysis of the suspension.*—The Volclay suspension was electrodialyzed for 1 week with a current of 0.1 amp. at 110 volts. At the end of 1 week the dialyzed material was removed from the membrane sack and redispersed with the mechanical stirrer.

3. *Chemical treatment of the dialyzed material.*—Sample 1: This sample (dry Volclay) was not treated, but used as received. A list of its exchangeable bases follows:

Cation—	Milli-equivalents per 100 g.
Na^+	83.35
K^+	5.30
Ca^{++}	24.00
Mg^{++}	0.85
Total (corrected for sulfates)	89.20

Sample 2: After electrodialysis, Sample 2 was dehydrated at 110° C. and subsequently pulverized in a hammer mill.

Sample 3: A small portion of the electrodialyzed material was weighed and dried at 110° C. to determine the percentage of solids. This facilitated calculation of the base-exchange capacity, inasmuch as it was known that the capacity of the Volclay was 89.20 milli-equivalents per 100 g. A sample containing 211 g. of solids, having a theoretical capacity to exchange 12.16 g. of potassium hydroxide, was agitated with the mechanical stirrer; 13 g. potassium hydroxide were dissolved in 1 l. of water and added to it, and stirring continued for 2 hours. The sample was permitted to stand for 1 week, with daily stirring to insure complete reaction. It then was dried at 110° C., and ground in the hammer mill.

Sample 4: The procedure with Sample 4 was similar to that for Sample 3. The capacity to exchange barium hydroxide was calculated and found to be 14.1 g. per 100 g. of solids; 114 g. of the hydroxide dissolved in 1 l. of water were added slowly to a sample containing 670 g. of solids. This provided an excess of 3 g. of barium hydroxide per 100 g. of solids. The sample was ground in the hammer mill after stirring and drying.

Sample 5: A wet specimen of heaving shale from the Hackberry field in Louisiana was subjected solely to drying and grinding in order to prepare it for test. This sample was taken at a depth of 8,470 ft.

Samples 6*a* to 6*i*, inclusive: Six specimens "as received" were dried carefully and compacted in the compression machine as described previously.

Test Procedure

The test was started by evacuating the reagent chamber. The time at which the chamber was filled and the level of the burette finally reached after the bomb filling were recorded. An additional burette filled with the same liquid was placed in the cabinet, and the change of level with time noted in order to check the effects of evaporation on burette readings.

As the test proceeded, liquid from the burette was absorbed by the blotter at the base of the sample and came in contact with the sample itself. The sample absorbed the liquid and, hence, increased in volume. The increase in volume was accompanied by pressure increase on the mercury in the chamber which was transmitted to the Bourdon tube. Tests were run at 110° F., which was maintained conveniently, and corresponded to well temperatures at a depth of approximately 2,400 ft. in the Gulf Coast (Fig. 4). There is nothing significant about this particular depth, but it was found desirable to choose a temperature in the range that might be encountered. However, the possible variation is shown by the fact that one shale tested came from a depth of somewhat over 8,000 ft. and a temperature of 210° F.

The five samples as prepared were each tested in the apparatus previously described. Distilled water was used as the reagent for all samples tested initially. The volume of reagent was read to the nearest 0.05 ml., and the pressure was determined to the nearest 10 lb. per sq. in. Check runs were made for all samples.

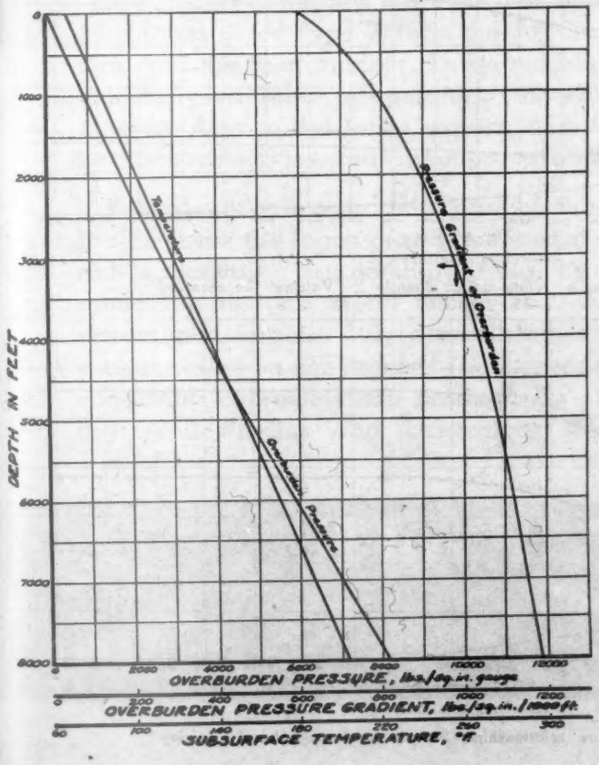
The present data are insufficient in both quantity and scope to justify any detailed observations on the behavior of bentonitic materials. The following observations, however, have been made:

1. The pressure-vs.-time relation (Fig. 5) during the first 15 hours of every test seemed to follow closely the empirical equation, $P = KT^n$, where P equals pressure, pounds per square inch; K equals a constant; T equals time, minutes; n equals an exponent.

It was found that for the materials investigated, K varied from 8.49 for heaving shale from the Hackberry field to 72.9 for electrodialyzed Volclay, and the values for n ranged from 0.743 for the Hackberry heaving shale to 0.482 for the Volclay. The Volclay samples, which possessed exchangeable bases, showed much less variation in n and K: 0.613 to 0.618 for n, 17.4 to 33.7 for K.

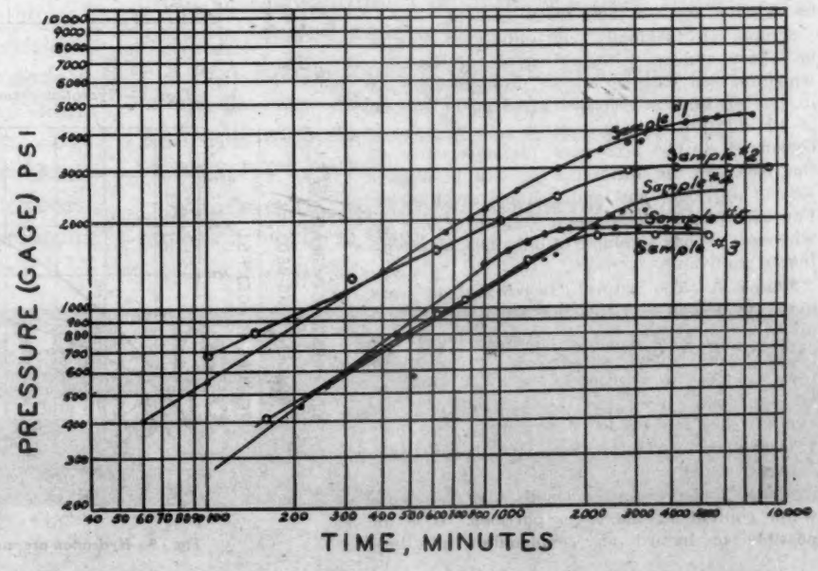
It is interesting to note that the curves of Samples 3 and 4 followed practically the same path during the first 15 hours of their tests. However at any given pressure, Sample 4 imbibed approximately 2½ times as much water as Sample 3. (See Figs. 6 and 7 on p. 220).

2. The pressures obtained clearly show the destructive potentialities of swelling bentonitic materials. It is probable that these values do not represent the maximum pressures obtainable, because the so-called "maximum" pressures recorded herein reflect equilibrium conditions only between the inherent pressure of hydration and the pressure already in the system due to swelling. Thus, in the present investigation, water continued to enter the sample until the *mechan-*



Left: Fig. 4—Depth-pressure-temperature relations

Below: Fig. 5—Comparison of hydration-pressure curves



ical pressure exerted within the apparatus due to the sample's tendency to expand was balanced exactly by the *hydration pressure* at the prevailing liquid concentration.

It should be noted that the absorbed liquid did not permeate the entire sample in the current investigation. A portion approximately $\frac{1}{16}$ in. thick immediately adjacent to the base plate seemed to retain all the liquid imbibed during the test. A similar phenomenon was observed in glass tubes of packed bentonite that were left open at the top and immersed in water at the bottom. The water rose into the sample only a short distance, and prolonged immersion produced no further rise.

Sample 1: The exchangeable bases of this present natural bentonite included 73.5 per cent Na^+, 21.7 per cent Ca^{++} and small amounts of Mg^{++} and K^+. A pressure of 4,700 lb. per sq. in. was obtained with the imbibation of 1.70 ml. of water (Fig. 8). It is to be expected that a clay containing large amounts of exchangeable Na^+ would swell with considerable increase in pressure, because of the hydrating power of the sodium.

Sample 2: It had been anticipated that treatment of the Volclay by electrodialysis would produce a so-called "hydrogen clay" in which most of the exchangeable bases of the original Volclay would be replaced by H^+. Such clays usually do not exhibit swelling properties once they have been dehydrated. However, it is evident from Fig. 9 that Sample 2 was quite capable of swelling. In fact, a test made with a small cake of it that had been compacted in a mechanical press showed a volume increase of 1,600 per cent at the end of 72 hours' immersion in distilled water.

Whether this phenomenon results from the possibility that many of the bases had not been exchanged for H^+, or whether some of the prevailing ideas about hydrogen clays are not valid, cannot be determined from the information available at present. The water consumption of Sample 2 in producing a pressure of 3,000 lb. per sq. in. was relatively high: 5.6 ml. This would be expected of a hydrogen clay, if it swelled, because the H^+ is very small and would leave much room for additional water molecules.

Sample 3: Electrodialyzed Volclay that had been treated with potassium hydroxide was expected to produce a clay having most of its bases exchanged for K^+. A pressure of 1,800 lb. per sq. in. was produced by the absorption of 2.05 ml. of water. Reference to the table of hydrodynamic radii will show that K^+ hydrates less strongly than Na^+ and, consequently, a lower swelling pressure for the potassium clay is to be expected for the same water content.

Sample 4: Originally electrodialyzed Volclay had been treated with an excess of $Ba(OH)_2$ which caused coagulation. A pressure of 2,500 lb. per sq. in. was recorded for a water content of 3.25 ml. This relatively large volume of water consumed can be accounted for apparently on the basis of the difference in size between a pair of univalent ions and a single divalent ion. For example, 2 Na^+ have a volume of 7.88 A^3, whereas Ca^{++} has a volume of only 4.99 A^3, according to Sullivan.[36]

Sample 5: The natural "heaving shale" sample from a well in Louisiana produced approximately 1,900 lb. per sq. in. for 2.5 ml. of absorbed water. The curves of "pressure vs. time" and of "water content vs. time" (Fig. 10) are unusually steep for this sample, the first curve rising rapidly to a maximum after only 1,700 minutes of elapsed time. Its curve of "pressure vs. water content" shown in Fig. 6 is very irregular, and reveals abnormally high values for water content in the lower portions. It is impossible to hazard any explanation of these anomalies, because the nature of the material and its exchangeable bases are unknown.

Before any attempt is made to correlate the behavior of the samples used in this work with the behavior of heaving shales in place, it should be noted that in the shales little if any of the

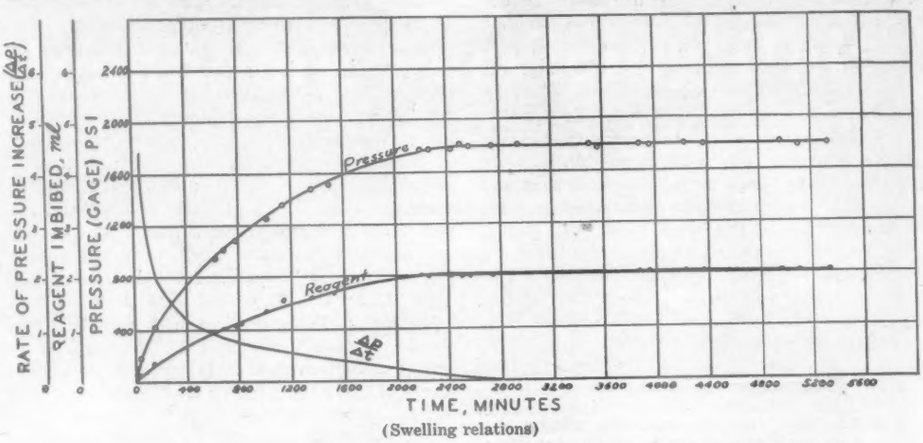


Fig. 6—Hydration-pressure relationships: Sample 3, electrodialyzed "Volclay"—KOH-treated

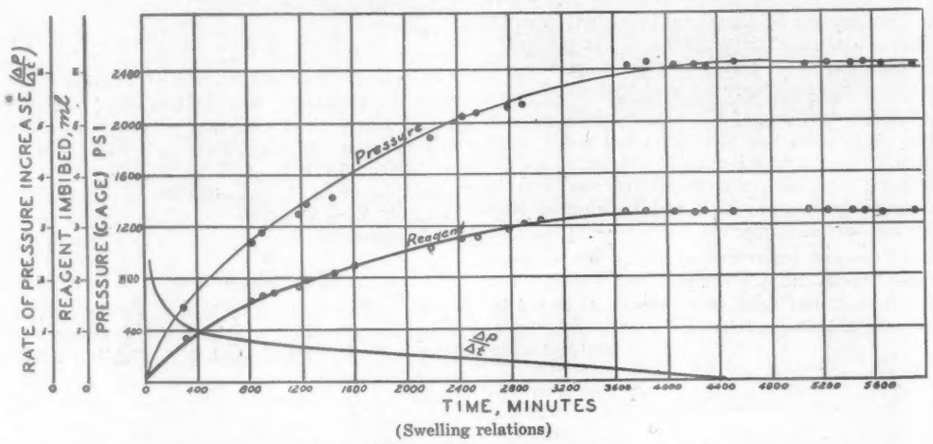


Fig. 7—Hydration-pressure relationships: Sample 4, electrodialyzed "Volclay"—$Ba(OH)_2$-treated

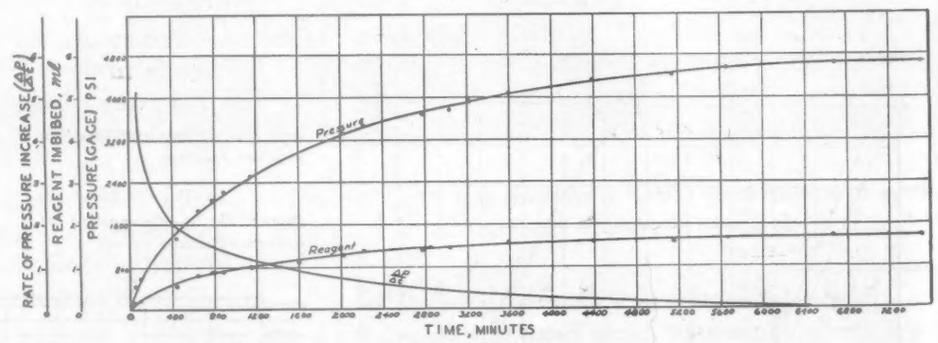


Fig. 8—Hydration-pressure relationships: Sample 1, "Volclay" as received

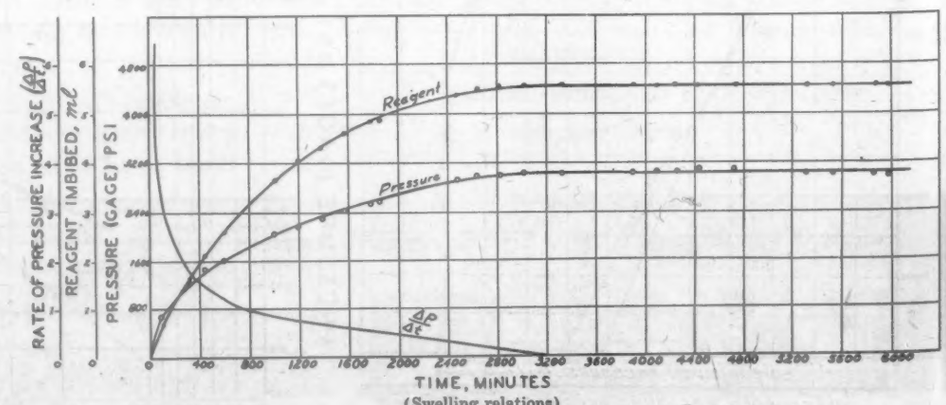


Fig. 9—Hydration-pressure relationships: Sample 2, electrodialyzed "Volclay"

WHAT'S A BRAND WORTH?

First of all a brand is valuable because it permits immediate identification. On each JoneSuckeRod or coupling there is a complete "case history", plainly marked. For instance: J for Jones, 7 for Type 7, then the API marking, size, and the heat number. These markings are extremely valuable to operators who keep rod records. Also to the Jones experts who "check back" on rod service, and thus improve rod quality.

Yet, identification is only part of the story. For 51 years the Jones brand has meant sucker rod leadership. Leadership? Yes, by developing the first all metal sucker rod, the first streamlined forging, fully normalizing, etc. By concentrating on one product—sucker rods—and constantly improving that product. By pioneering Well Studies and Laboratory Research through advanced Engineering and Metallurgy.

Today the S. M. Jones Company is taking its place in the war effort — the third war in the company's history. Nearly two years ago Uncle Sam recognized the value of the Jones brand by asking the company to turn out war goods which required precision manufacture. With characteristic vision Jones management enlarged facilities and increased personnel, in order that availability of materials only would limit sucker rod production.

Again, today, Jones is leading in a campaign to aid the war effort by helping oil men everywhere to increase the efficiency and service life of rods now in use.

What's a brand worth? Whatever its owner makes it worth to you.

The S. M. JONES Co.

JoneSuckeRods

General Office and Factory, Toledo, Ohio — Sales Office, McBirney Bldg., Tulsa, Okla.

Banks HAVE HELPED AMERICA

IN EVERY WAR . . . . .

From 1776 to 1942—from the American Revolution to World War No. II—America's banks have played a prominent part in every war fought by the United States. And today, America's banking industry is measuring up to its biggest opportunity—its greatest responsibility—that of banker, backer and fiscal agent for Uncle Sam.

This bank, too, is doing everything possible to help win the present conflict: making government loans, buying War Bonds, financing oil industry operations and the production of war equipment.

NATIONAL BANK OF TULSA

The Oil Bank of America

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

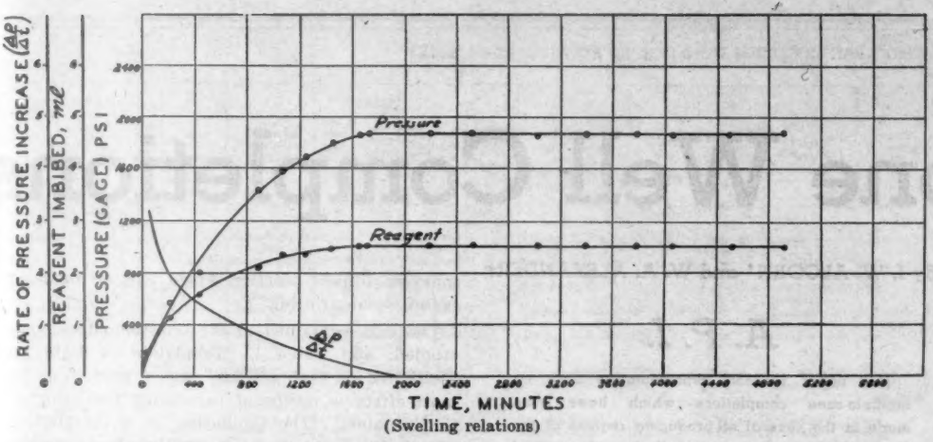


Fig. 10—Hydration-pressure relationships: Sample 5, "heaving shale"—from Hackberry field, Louisiana

void space is occupied by air, whereas in the samples most of the voids are air-filled.

Fig. 11 shows the pressure-time relations obtained by the treatment of 20-g. samples of Wyoming bentonite "as received" and precompressed as before. The samples were treated with 0.5 normal solutions of sodium hydroxide, potassium hydroxide, calcium hydroxide, and barium hydroxide, respectively. The action of these bases on the sample are, apparently, predictable. For example, addition of a base results in an increase of thickness of the double layer, and increases the charge. The charge on each clay particle, and, hence, the degree of deflocculation or potential swelling power, are dependent upon the thickness of the outer layer of the micelle. This distance is normally inversely proportional to the valence of an ion, hydrogen being an exception to the rule, and less swelling is to be expected from divalent and trivalent bases than from monovalent bases.[31]

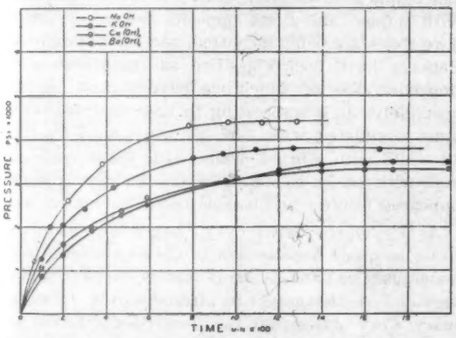


Fig. 11—Swelling relations—comparative effect of various bases, N = 0.5

In the present experimental work, the bentonite exhibited swelling tendencies as predicted, inasmuch as the highest pressure was obtained using sodium hydroxide, whereas calcium and barium hydroxides yielded lower values, and potassium hydroxide gave an intermediate value. It is probable that if the average of several runs, rather than the results of two individual runs were plotted, the irregular crossing of the calcium and barium-hydroxide curves would be eliminated.

The reduction of the sample weight from 28 g. to 20 g. made it possible to attain the maximum pressure more quickly with complete saturation of the electrolyte. The reduction in size of the sample also resulted in maximum pressures within gage capacity.

A series of runs made with water, 0.5 N HCl, 0.5 N NaOH, and 0.5 N NaCl as wetting agents, showed that the pressure-hydration relationship was predictable.

Fig. 12 shows the pressure-time relationship when samples of the Volclay, compressed as before, were treated with various reagents. Each curve represents the average of several check runs. Care was taken to control all tests and to eliminate all doubtful results.

Curves 1, 2, 3, and 4 show the results obtained from water, 1 N $Na_2H_2P_2O_7$, 1 N NaCl, and 0.5 N KCl, respectively. The curves lie so closely to one another that difficulty exists in differentiating the effects of the various reagents.

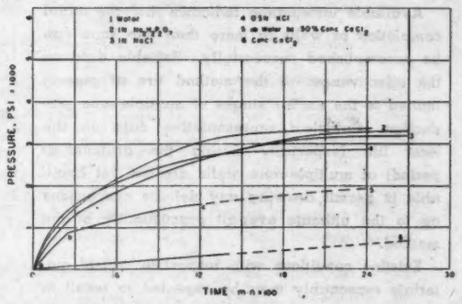


Fig. 12—Swelling relations—comparative effects of various reagents

In the case of Curve 5, the portion *ab* was due to the absorption of distilled water. The water was removed from the pressure bomb at *b*, and a solution of 50 per cent saturated calcium chloride substituted. The pressure increase proceeded from *b* to *c* at a greatly decelerated rate as shown by the curve, with an equilibrium value of approximately 50 per cent of Curve 1.

Curve 6 shows the results of using a saturated solution of calcium chloride. The maximum equilibrium pressure, as projected, is approximately 20 per cent of that shown for Curve 1.

Conclusion

The present work was intended only as an extended test of the hydration-pressure bomb. No single line of investigation has been followed rigidly. It is expected that future work with the bomb will make possible more thorough investigations, particularly from the standpoint of pressure reduction by means of added chemicals.

From the data gathered, the following conclusions have been drawn:

1. Materials of the type represented by Wyoming bentonite are capable of producing pressures of considerable magnitude when confined during hydration.

2. Although the data on this point are not conclusive, it is thought that the nature of the exchangeable bases present will determine to a large extent the swelling-pressure characteristic of a clay material.

3. A study of existing information regarding the increase of thickness and charge of the outer layer of the micelle as influenced by added electrolytes may provide a means for predicting relative maximum pressures attainable in the apparatus described. Additional experimental work will be of interest concerning such predictions.

4. In the early states of hydration, the swelling process follows a relationship of the type:

$$P = KT^n$$

References

1. Bull. "Data No. 202," Am. Colloid Co., Chicago, Ill.
2. H. H. Power and Charles R. Houssiere, Jr., "A Preliminary Survey of the Heaving-Shale Problem," A.P.I. Division of Production Paper No. 901-17E, Feb. (1941).
3. Ch. von Ludeking, "Ueber das physikalische Verhalten von Losungen der Colloide," Ann. Phys. Chem., 35 (1888).
4. E. von Wiedemann and Ch. von Ludeking, "Ueber die Warmeentwickelung bei der Quellung und Losung der Colloide," Ann. Phys. Chem., 25 (1885).
5. Reinke, Hanstein's botan, Abhandl., 4 (1879).
6. H. Rodewald, "Thermodynamik der Quellung mit apexieller Anwendung auf die Starke and deren Molekulargewichtsbestimmung," Z. physik. Chem., 24 (1879).
7. C. A. Schull, "Semipermeability of Seed Coats," Botan. Gaz. 56 (1913).
8. H. R. Kruyt and H. S. van Klooster, Colloids, John Wiley & Sons, New York (1927).
9. E. von Posnjak, "Ueber den Quellungsdruck," Kolloidchem, Beihefte 3 (1912).
10. F. E. Bartell and L. B. Sims, "The Relation of Anomalous Osmose to the Swelling of Colloidal Material," J. Am. Chem. Soc. 44 (1922).
11. A. W. S. Thomas, Colloid Chemistry, McGraw-Hill Book Co., New York (1934).
12. H. R. Proctor and J. A. Wilson, "The Acid-Gelatin Equilibrium," J. Chem. Soc. 109 (1916); H. R. Proctor, "The Equilibrium of Dilute Hydrochloric Acid and Gelatin," J. Chem. Soc. 105 (1914); J. A. Wilson and W. H. Wilson, "Colloidal Phenomena and the Adsorption Formula," J. Am. Chem. Soc. 40 (1918).
13. J. H. Northrop and M. Kunitz, "The Swelling Pressure of Gelatin and the Mechanism of Swelling in Water and Neutral-Salt Solutions," J. Gen. Physiol. 10 (1927); J. H. Northrop and M. Kunitz, "The Swelling of Isoelectric Gelatin in Water," J. Gen. Physiol. 10 (1927); J. H. Northrop and M. Kunitz, "The Swelling and Osmotic Pressure of Gelatin in Salt Solutions," J. Gen. Physiol. 8 (1926); J. H. Northrop, "The Swelling of Isoelectric Gelatin in Water," J. Gen. Physiol. 10 (1927); and M. Kunitz, "Hydration of Gelatin in Solution," J. Gen Physiol. 10 (1927).
14. R. Chiari, "Untersuchungen uber physikalische Zustansanderungen der Kolloide," Boichem. Z. 33 (1911).
15. J. Loeb, Proteins and the Theory of Colloidal Behavior, McGraw-Hill Book Co., New York (1922).
16. H. B. Weiser, Colloid Chemistry, John Wiley & Sons, New York (1939).
17. Hofmeister, Arch. exp. Path. Pharmakol. 24 (1888).
18. J. R. Katz, "Die Gesetze der Quellung," Kolloidchem. Beihefte 9 (1917-18).
19. H. Freundlich, Kapillarchemie, Akademische Verlags Gesellschaft, M. B. H., Leipzig (1922).
20. Karl von Terzaghi, The Mechanics of Adsorption and of the Swelling of Gels, 4th Colloid Symposium Monograph, The Chemical Catalog Co., New York (1925).
21. Karl von Terzaghi, "The Influence of Elasticity and Permeability on the Swelling of the Two-Phase Systems," J. Alexander, Colloid Chemistry 3, The Chemical Catalog Co., New York (1931).
22. U. Hofmann, K. Endell, and D. Wilm, "Kristallstruktur und Quellung von Montmorillonit," Z. Krist, 86 (1933).
23. W. F. Bradley, R. E. Grim, and G. L. Clark, "A Study of the Behavior of Montmorillonite Upon Wetting," Z. Krist. 97 (1937).
24. E. von Posnjak, "Ueber den Quellungsdruck," Kolloidchem. Beihefte 3 (1912).
25. H. Jenny, "Studies on the Mechanism of Ionic Exchange in Colloidal Aluminum Silicates," J. Phys. Chem. 36, July-Dec. (1932).
26. J. D. Sullivan, "Physico-chemical Control of Properties of Clays," Trans. Electrochem. Soc. 75 (1929).
27. E. A. Hauser, paper presented before 43d annual meeting, Am. Ceramic Soc., Baltimore, Md., Mar. (1941).
28. H. H. Power and Charles R. Houssiere, Jr., "Chemical Treatment of Bentonitic Suspensions and the Relationship of the Heaving-Shale Problem," Am. Inst. Mining Met. Engrs. Tech. Pubi. 1401, Nov. (1941).
29. H. H. Power, B. Towle, and Joseph Plaza, "A Method for Measuring Hydration-Pressure Relationships in Bentonitic Materials and Heaving Shale," Univ. Texas Bull. Bur. Eng. Research 33 (1942).
30. Bull. "Data No. 216-C," Am. Colloid Co., Chicago, Ill.
31. A. L. Johnson and F. H. Norton, "Fundamental Study of Clay—I. Preparation of a Purified Kaolinite Suspension; II. Mechanism of Deflocculation in the Clay-Water System," J. Am. Ceramic Soc., Mar. 30 to Apr. 5 (1941).

A Review of

Multiple-Zone Well Completions

By I. W. ALCORN* and W. A. ALEXANDER†

A. P. I.

This paper presents representative data on multiple-zone completions which have been made in the several oil-producing regions of the United Sates. It is a joint effort of the topical committees on drilling and production practice, and constitutes a progress report on the subject.

The desire of the oil industry to find ways and means of conserving steel in its drilling and production activities led to the decision to undertake this survey. An analysis of 89 multiple-zone completions indicates that an average per-well saving of 105 tons, or 46 per cent, was realized in a multiple-zone completion, in comparison with two standard well completions.

Available information indicates that the initial completion of wells in more than one zone can be accomplished successfully. Reliable data on the effectiveness of the method are at present limited to the earlier stages of multiple-zone production. Sufficient representative data on the later life (especially during the artificial-lift period) of multiple-zone wells are not yet available to permit drawing any definite conclusions as to the ultimate over-all practicability of the method.

Existing conditions with respect to critical materials reasonably may be expected to result in an accelerated development of improved technique and more advanced methods of application.

Paper presented before Division of Production at the annual meeting of the American Petroleum Institute, Chicago, Ill., November 9-13.

AT the spring meeting of the southwestern district of the Institute's Division of Production, in Dallas, Tex., in February 1942, a number of suggestions were advanced as to ways and means of producing more oil with less use of critical materials, it having been agreed unanimously that for the duration of the war all projects undertaken by the committees of the southwestern district should be in direct support of the war effort.

Prominent among these suggestions was a study of dual or multiple-zone completions; however, no decision was reached at that time as to the advisability of a paper on this subject. In the 5 months' period following the meeting a growing interest has been manifested in the subject due to the increasing scarcity of steel. In view of the wide interest exhibited, such a survey appeared to be warranted, inasmuch as the experience and data accumulated by operators having made multiple-zone completions were not available generally to the industry.

Subsequently it was decided that the topical committees on drilling and production practice jointly would undertake a statistical survey of data on multiple-zone completion practices as a contribution to the petroleum industry. The two committees prepared a questionnaire which was forwarded to all operators who have made multiple-zone completions. The executed questionnaires which were returned to the committee supplied the basic data used in this paper, which is to be considered as a progress report.

It is not the purpose of this survey to investigate the merits of multiple-zone completions or to offer recommendations as to general applicability of the method. Instead, the objective of the study was to present basic data made available to the committees mainly from the viewpoint of methods, equipment employed, the initial degree of success achieved, and difficulties experienced. It may well be that the desire or necessity to expend the minimum amount of critical material will lead to wider adoption of multiple-zone completions where the method can be employed successfully. Therefore, it is hoped that the data presented herein may be of some assistance as a guide to operators electing to make multiple-zone completions who have not had previous experience with the method.

Objectives of a Multiple-Zone Completion

A multiple-zone completion is considered herein as a means whereby two or more separate oil or gas-bearing formations are exploited simultaneously in the same well. Under normal conditions the reason prompting completion of a well in more than one zone usually would be either:

1. Economic: Initial investment required is substantially less for a multiple-zone completion than the expenditure necessary for drilling separate wells to the individual zones.

2. Regulatory: Spacing, or other restrictions imposed by regulatory bodies governing the number of wells permitted in defined surface areas.

However, under conditions existing at present, an important new reason for giving consideration to multiple-zone completions is the necessity for conserving steel.

Presentation of Data

Executed questionnaires were received covering multiple-zone completion of 89 wells in several of the different oil-producing districts of the United States. Obviously, all wells in which multiple-zone completions have been made in these areas were not reported on, but it does appear that a reasonable cross-section was obtained, so that the data supplied should be representative and reliable.

Multiple-zone completions in California and Illinois are not included in the 89 wells previously referred to. Cory's* recent paper (given at the annual meeting of the Institute in November 1941) appears adequately to have covered California practice; moreover, a relative small number of questionnaires was received from California.

In Illinois the very large number of multiple-zone completions, together with the wide range in procedure, indicated that questionnaire compilation of data would not be feasible. Instead, R. J. Sullivan, of Carter Oil Co., and Marshall Joy, of Cities Service Oil Co., prepared a summary of Illinois practice which will be included before final printing.

The data contained in the questionnaires were studied, and Table 1, "Tabulation of Data on Multiple-Zone Completions," was prepared as the most effective means of presenting the information obtained. The tabulation is a compilation of all data submitted on multiple-zone completions in the Gulf Coast, East Texas, West Texas, Oklahoma-Kansas, and Arkansas-North Louisiana areas.

Table 2 was prepared in order to highlight the more important features of Table 1.

From Table 2 it will be observed that of the 89 dual completions, 63 set casing through both zones and 26 set casing between zones. Sixty-nine of the wells used unloading valves of the Lewis and Otis variety. Only five were equipped with screen, and these opposite the lower zone. Two zones are being gas-lifted, and seven pumped. Packers have been classified as removable and nonremovable, of which we have 65 and 24, respectively. It is interesting to note that 50 wells were completed with 7-in., 24 wells with 5½-in., 12 wells with 6-in., 2 wells with 6⅝-in., and 1 well with 8⅝-in. casing. The smaller casing sizes appeared to offer no obstacle to dual completions.

As previously stated, Cory's paper is considered to be adequate for a review of California multiple-zone practice, and is more comprehensive than any analysis that might be offered herein. In summary, Cory states that the trend in California is away from multiple-zone completions, and the present feeling is that it should be used only in special cases justified by local expediency. This conclusion would appear to be based on difficulties experienced in producing multiple-zone wells during both flowing and artificial-lift periods. The questionnaires received from California appear to substantiate Cory's conclusions quite well. It is indicated that most of the multiple-zone wells now are producing from one zone only, even though the original completion was in two or three zones. The opinion is expressed by California operators that multiple-zone completions there might result in reduced ultimate recoveries per zone as compared to single-zone completions.

It is recognized that operating conditions as related to multiple-zone completions differ greatly between California and the Mid-Continent areas. Inability to put the two areas on a comparable basis is indicated by: (1) Differences in rules issued by state regulatory bodies governing completion practices; (2) wide variance in proration plans, especially with regard to potential ratings; and (3) nonuniformity in production reservoir characteristics such as nature and thickness of producing zone sections, viscosities of oils, etc.

The principal reason for multiple-zone completions as reflected in the Mid-Continent questionnaires was economy. The economies effected have been in the nature of reduced drilling costs, savings in casing and tubing, drilling equipment, lease roads, flow lines, dredging canals, derricks, pumping units, etc. In most instances the standard casing program was found to be about the same as that selected for the dual completion.

From the questionnaires it was observed that,

*Pure Oil Co., Houston, Tex. †Shell Oil Co., Inc., Houston, Tex.

*Robert F. Cory, "A Review of Multiple-Zone Production in California," Proc. A.P.I. 22 (4) 14 (Production Bull. 228) (1941).

TABLE 1—TABULATION OF DATA ON MULTIPLE-ZONE COMPLETIONS

Field	Number of Wells	Date Completed	Reason for Multiple-Zone Completion	Average Depth	Interval Between Zones (1) and (2)	Type of Formation of Zones (1)	Type of Formation of Zones (2)	Casing Size (Oil String)	Point at which Casing was Set	Tubing Size	Screen	Type of Packer Used	Type of Unloading Valve	Daily Rates of Production Zones (1)	Daily Rates of Production Zones (2)	Producing	Production Method Zones (1)	Production Method Zones (2)	Savings—Dual Well Compared to Two Single Wells: Steel Per Cent	Steel Tons	Cost (Per Cent)
Gulf Coast Area—Texas				(Feet)	(Feet)			(Inches)		(Inches)											
La Gloria	10*	Early 1941	Planned cycling program	6,500	600	Sand	Sand	7	Through both zones	4½ and 1¼	None	Removable	Lewis	10,000 MCF	6,500 MCF.	Simultaneously	Natural flow	Natural flow	42	132	32
Stratton	17	Early 1941	Planned cycling program	6,500	20	Sand	Sand	7	Through both zones	4½ and 1¼	None	Removable	Lewis	5,000 MCF	5,000 MCF	Simultaneously	Natural flow	Natural flow	42	132	32
Katy	3	7/42	Scarcity of material	7,400	100	Sand	Sand	7	Between zones	2½	Lower zone	2 non-removable 1 removable	Otis	20,000 MCF	10,000 MCF	Simultaneously	Natural flow	Natural flow	30	62	25
La Rosa	1	4/41	Obtain fuel gas	5,800	200	Sand	Sand	7	Through both zones	2½ and 1¼	None	Non-removable	Use 1¼-in. tubing	3,000 MCF	3,000 MCF	Simultaneously	Natural flow	Natural flow	34	28	40
Dickinson	1	1/42	Obtain additional source gas	8,000	50	Sand	Sand	7	Through both zones	2½	None	Non-removable	Otis	2,500 MCF	1,500 MCF	Simultaneously	Natural flow	Natural flow	49	193	38
Naubro	1	10/41	Economy	5,200	60	Sand	Sand	7	Through both zones	2½	None	Non-removable	None	1,500 MCF	70 bbl oil	Simultaneously	Natural flow	Natural flow	41	67	35
West Ranch	1	4/40	Economy	5,700	700	Sand	Sand	7	Through both zones	2½	None	Non-removable	Brown equalising valve	700 MCF	50 bbl oil	Simultaneously	Natural flow	Natural flow	30	49	40
Jackson County	2	1940-1941	Obtain fuel gas	5,200 5,900	50	Sand	Sand	5½	Between zones	2	Lower zone	Removable	None	800 MCF	40 bbl oil	Simultaneously	Natural flow	Natural flow	50	71	45
Anahuac	1	9/35	Obtain fuel gas	7,000	300	Sand	Sand	7	Between zones	2½	Lower zone	Removable	None	.....	35 bbl oil	Lower only	Natural flow	Natural flow	50	135	44
Fort Neches	1	6/41	Gas for lease operations	3,500	1,400	Sand	Sand	5½	Through both zones	2	None	Removable	Otis	700 MCF	100 bbl oil	Simultaneously	Natural flow	Natural flow	50	62	45
Odem	1	11/41	Economy	5,300	1,800	Sand	Sand	5½	Through both zones	2	None	Removable	Otis	. . . . .		Intermittently	Natural flow	Natural flow	.....	.....	.....
Louisiana:																					
Chemeyville	1†	8/38	Economy	6,000	75	Sand	Sand	8⅝	Through both zones	2½	None	Removable	Otis	100 bbl oil	100 bbl oil	Together	Gas lift	Gas lift	.....	.....	.....
Hackberry	1	6/42	Scarcity of material	9,200	200	Sand	Sand	7 and 5 liner	Through both zones	2½ and 2	None	Removable	Otis	75 bbl oil	75 bbl oil	Simultaneously	Natural flow	Natural flow	49	143	45
White Lake	1	4/42	Economy	6,500	450	Sand	Sand	5½	Through both zones	2	Lower zone	Non-removable	Otis	176 bbl oil	187 bbl oil	Simultaneously	Natural flow	Natural flow	48	93	45
Ville Platte	10‡	Early 1941	Offset obligations	8,900	150	Sand	Sand	6	Through both zones	2 and 2½	None	Non-removable	Otis	40 bbl oil	120 bbl oil	Simultaneously	Natural flow	Natural flow	50	120	45
Ville Platte	2	6/42	Economy	10,000	1,150	Sand	Sand	6	Through both zones	2 and 2½	None	Non-removable	Otis	80 bbl oil	100 bbl oil	Simultaneously	Natural flow	Natural flow	46	142	45
Anse La Butte	1	2/42	Economy	6,000	100	Sand	Sand	5½	Through both zones	2	None	Non-removable	Otis	150 bbl oil	165 bbl oil	Simultaneously	Natural flow	Natural flow	50	78	47
East Texas Area—																					
Carthage	1	8/42	Economy	5,900	1,000	Sand	Sand	5½	Through both zones	2	None	Non-removable	Otis	2,400 MCF	1,000 MCF	Alternately	Natural flow	Natural flow	46	155	45
Chapel Hill	1§	Early 1942	Economy	8,000	2,300	Sand	Lime	5½	Through both zones	2	None	Non-removable	Otis	Shut in	74 bbl oil	Lower only	Shut in	Natural flow	44	87	11
Chapel Hill	1	Early 1942	Economy	8,000	2,300	Sand	Lime	5½	Through both zones	2	None	Non-removable	Circulation joint	Shut in	74 bbl oil	Lower only	Shut in	Natural flow	44	96	30
Chapel Hill	1	2/42	Economy	8,000	2,300	Sand	Lime	7	Through both zones	2½	None	Removable	None	5,000 MCF	74 bbl oil	Simultaneously	Natural flow	Natural flow	15	29	40
Long Lake	4	1940	Economy and planned cycling program	5,300	20	Sand	Sand	7	Between zones	2½	None	Removable	None	6,000 MCF	45 bbl oil	Simultaneously	Natural flow	Natural flow	50	133	..
Long Lake	7	1940	Economy and planned cycling program	5,300	40	Sand	Sand	5½	Between zones 5 and 2 through both	2	None	Removable	Otis	6,000 MCF	45 bbl oil	Simultaneously	Natural flow	Natural flow	52	96	48
Long Lake	7	1940-1942	Economy and planned cycling program	5,300	20	Sand	Sand	5½ (5); 7 (2)	Through both zones	2	None	Removable	Otis	4,000 MCF	10 to 10,000 MCF	Simultaneously	Natural flow	Natural flow	52	95	48
Cayuga	3	1941	Economy and planned cycling program	4,000	150	Sand	Sand	6⅝ (2) 5½ (1).	Between zones	2	None	Removable	Otis	8,000 MCF	50 bbl oil	Simultaneously	Natural flow	Natural flow	50	52	48
West Texas Area—																					
Kimble County	1	7/42	Economy	1,500	150	Sand	Sand	8⅝ and 5 liner	Through both zones	2½	None	Removable	None	Shut in	4 bbl oil	Lower only	Shut in	Natural flow	41	25	37
Kermit and Estes Kansas-Oklahoma Area—	2	Early 1941	Gas for artificial lift	2,500	200	Sand	Sand	7	Between zones Set through lower zone not cemented	2½ and 1½	None	Removable	None	250 MCF	4 bbl oil	Simultaneously	Natural flow	Gas lift	48	48	48
Ramsey	1	8/41	Offset obligation	4,800	200	Lime	Sand	5½	Between zones	2½	None	Removable	None	24 bbl oil	15 bbl oil; 288 bbl water	Simultaneously	Natural flow	Pumping	50	56	48
Gurney	1	5/41	Economy	3,150	175	Lime	Sand	7	Between zones	2½	None	Non-removable	None	32 bbl oil	38 bbl oil	Intermittently	Pumping	Pumping	50	66	46
Trapp	1	7/42	Increase in allowable	3,300	200	Lime	Lime	7	Between zones	3	None	Non-removable	None	155 bbl oil 3 days	140 bbl oil 15 days	Intermittently	Pumping	Pumping	47	39	42
Anschutz Arkansas-North Louisiana Area—	1	4/41	Offset obligation	3,300	250	Lime	Lime	7	Between zones	2	None	Non-removable	None	36 bbl oil	32 bbl oil 33 bbl water	Intermittently	Pumping	Pumping	50	56	46
Rodessa	1	12/36	Obtain gas for fuel	6,000	150	Lime	Lime	7	Through both zones	2½	None	Removable	Otis	2,000 MCF	225 bbl oil	Simultaneously	Natural flow	Natural flow	50	144	46
Shuler	1	5/42	Test feasibility of dual completion	6,800	120	Sand	Sand	7	Through both zones	2½	None	Non-removable	None	100 bbl oil	2,000 MCF	Simultaneously	Natural flow	Natural flow	50	..	50

* Three of these wells used for injection purposes. Volumes as high as 20,000 MCF for each zone returned to formation.
† Well produced zones individually on natural flow, but combined when natural flow ceased and placed on gas lift.
‡ Much difficulty experienced in effecting dual completion. Eight attempts to set various packers had been made before successful seal was obtained.
§ Several of these wells at one time were or now are being used as gas-injection wells in a pressure-maintenance project. The lower zone in one of the wells is being produced by gas lift through a string of 1¼-in. tubing at 4,250 ft inside of 2½-in. tubing.

in many of the wells, squeeze cementing was resorted to before attempting to complete in more than one zone. There were 17 cases reported of squeeze cementing between zones, 5 above the top zone, and 8 opposite or below the lower zone. It is obvious that the purpose of the 17 squeeze jobs between zones was to insure a complete shutoff between them, whereas the other 13 squeeze jobs may have been performed to shut off gas or water. Some difficulties have been experienced with sand cutting the tubing opposite the upper zone. Most of the operators now are attempting to overcome this trouble by covering the portion of the tubing opposite the upper zone with a rubber or neoprene sleeve, although some have installed as a substitute a pipe sleeve over the tubing.

Generally, no serious difficulties were experienced in making the initial multiple-zone completions. Most of the troubles reported were with packer settings, and these apparently were of a temporary nature, with final successful results. No evidence was submitted which would indicate commingling of zones due to leakage around the packer after it had been set.

The more commonly reported difficulties in completing and producing multiple-zone wells are as follows:

1. Sand cutting the tubing opposite the upper zone, resulting in commingling.
2. Difficulty in setting packers.
3. Some instances of stuck packers.
4. Cases of trouble in pulling or seating bottom-hole choke; also in swabbing the well in, both due to sand plugging the side-door choke.
5. Few cases of producing both zones through the tubing in order to prevent paraffin deposition in annulus.

Attention is directed to the fact that, of the 89 multiple-zone wells studied, only 9 zones in total were being produced by artificial lift, 2 by gas lift, and 7 by pumping.

The seven zones being pumped are in wells in the Oklahoma-Kansas area. Present practice is intermittent production of each zone separately, by pumping through the tubing. During the first 15 days, the month's allowable may be pumped from the lower zone, after which the tubing is raised enough to bring the perforations in the tubing above the packer; then the allowable for the upper zone is pumped the latter half of the month. Up to date this practice has been entirely satisfactory.

The questionnaires contained a request for the operators' plans regarding artificial lift. Thus far most of the operators do not seem to have planned a program as to the manner in which artificial lift will be applied to the individual zones when this stage of production becomes necessary. A

TABLE 2—MISCELLANEOUS SUMMARY

Type of completion: Upper zone	Lower zone	No. of wells	Casing through both zones: Size (In.)	Casing between zones: Size (In.)	Removable packers	Nonremovable packers	No. of unloading valves	No. of screens	No. of gas-lift zones	No. of pumping zones
Gas	and gas	40	21—7 6—5½	3—7	35	5	39	1	0	0
Gas	and oil	28	4—7 6—5½	7—7 9—5½ 2—6⅝	24	4	14	3	1	0
Oil	and gas	1	1—7	..	0	1	0	0	..	0
Oil	and oil	17	1—8⅝ 9—6 2—5½	4—7 1—5½	3	14	13	1	1	7
Gas and oil (input)		3	3—6	..	3	0	3	0	0	0
Total		89	63	26	65	24	69	5	2	7

few seem to feel that pressures in the two zones will be equalized sufficiently by the time artificial lift is necessary to permit the zones to be produced together as one operation. Others offer the opinion that the zones may have to be produced artificially one at a time and separately, say the lower first and the upper one later. Still others comment that both zones will be separately and simultaneously lifted artificially; for example, by gas lifting the upper zone by means of a macaroni string in the annulus, and by pumping the lower zone through the tubing.

Methods of Equipment

On account of wide common usage, the term "multiple-zone completion" has been used throughout this paper. Actually, however, all 89 of the wells included in the study were completed in only two zones; hence, they might more properly be termed "dual completions."

The increasing use of the multeple-zone completion method has resulted in the development of different techniques and the availability of various kinds of equipment. In the normal course of a multiple-zone completion there are but two major items of equipment which usually would not be used in a single-zone well. These two pieces of equipment, of course, are the packer set between the two producing zones, and the unloading valve. A description briefly outlining several typical dual-completion methods, with emphasis on the purpose and type of special equipment such as packers and unloading valves, is given hereinafter.

It will be appreciated that the methods and equipment described are not to be construed as recommendations of the authors, but simply as a means of illustrating some of the various methods followed and equipment utilized. It is hardly necessary to point out that conditions existing in an individual well, together with the particular purpose of the dual completion to be made and the operator's judgment, will be the determining influence on choice of method and equipment.

Typical Dual Completion Using Permanent (Nonremovable) Packer

General.

This method, shown in Fig. 1, is the simplest type of dual completion. The lower zone may be

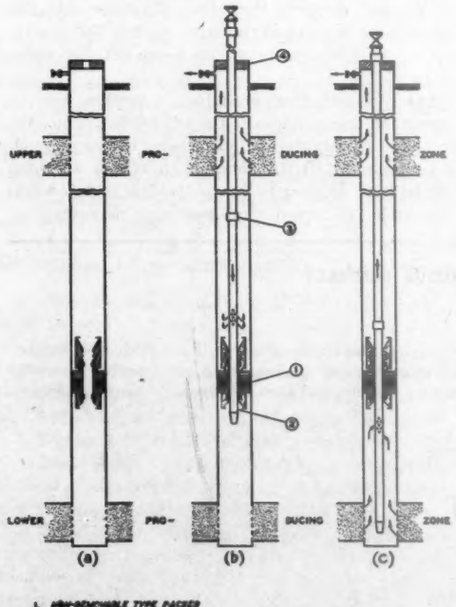


Fig. 1—Typical dual-well completion method—using nonremovable type of packer

screened as shown in Fig. 2, if desired. A side-door choke or similar upper inlet (unloading) valve also may be used in conjunction with this method. It is assumed that both zones have been suitably perforated and treated, tested, or otherwise prepared for completion.

Operation 1: Fig. 1(a).

This operation consists of running and setting the permanent-type packer at the desired position in the well.

Operation 2: Fig. 1(b).

The tubing with the tail pipe, which is finally to seal off in the packer body, is run into the well until the anchor pipe is through the packer at about its final position. The tubing then is raised sufficiently to place the tail-pipe perforations above the packer. The upper zone then is washed or swabbed into production.

Operation 3: Fig. 1(c).

The tubing now is lowered sufficiently to place the perforations below the packer, and tubing hung on the tubing head. The lower zone then is swabbed into production.

Typical Dual-Completion Method Using Permanent (Nonremovable) Type Packer

General.

Fig. 2 shows another kind of typical dual com-

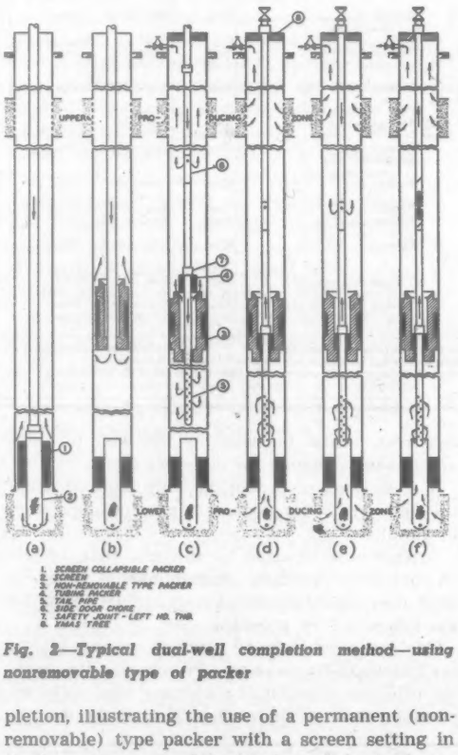


Fig. 2—Typical dual-well completion method—using nonremovable type of packer

pletion, illustrating the use of a permanent (nonremovable) type packer with a screen setting in the lower zone. An Otis side-door choke is shown as one type of unloading valve. The operation is unchanged in cases in which the screen is not used [Fig. 2(a)], and the lower screen and packer [Fig. 2(b) to (f)] merely being eliminated. Various makes of packers and other accessories are available for this type of completion. It is assumed that both zones have been suitably perforated and treated, tested, or otherwise prepared for completion.

Operation 1: Fig. 2(a).

The screen and liner are run into the hole on drill pipe or tubing, a partial washing job made by spotting a safe amount of water, the screen and liner released, the liner packer collapsed, and the drill pipe removed.

Operation 2: Fig. 2(b).

The permanent interzone packer then is run in on tubing or drill pipe, the mud above the packer is conditioned, and the packer is set in the desired position. The tubing or drill pipe and setting tool then are removed.

Operation 3: Fig. 2(c).

Tubing then is run back into the hole with the tail pipe, inner packoff, safety joint, and side-door choke, or equivalent material, assembled as shown in Fig. 2(c). The tubing seat is located, and the tubing-hanger nipple inserted at the correct spacing for hanging. The tubing packer then is lowered to a point close to its final setting point, and washing is started and continued until the well flows through the annulus.

Operation 4: Fig. 2(d).

Circulation is stopped, the tubing packer is set and locked, and the tubing hung.

Operation 5: Fig. 2(e).

If the well stops flowing through casing, oil or gas may be circulated through the side-door choke until the well is flowing again. Circulation is stopped, and the well flows or may be swabbed in through the tubing until strong flow is established.

Operation 6: Fig. 2(f).

When both tubing and casing are flowing sufficiently, the tubing is closed in, and a blank bean run into the side-door choke. This separates the tubing flow from that in the annular space. Swabbing might be necessary to reestablish flow in the tubing, and this may be carried out in the usual manner until the well may be put on production.

Typical Dual-Completion Method Using Lewis Valve

General.

Fig. 3 shows a typical dual-completion method

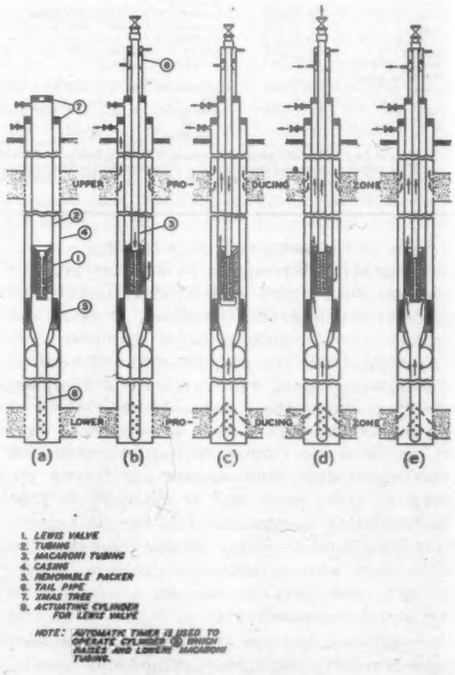


Fig. 3—Typical dual-well completion method — using Lewis valve

which is representative of a number of successful installations, using a removable-type packer and the Lewis unloading valve. This latter device was developed for special application to gas-distillate wells for the purpose of removing condensate from the annulus. In wells in which this device has been used, the casing string has been 7-in. with a 4½-in. tubing string as the intermediate string and 1¼-in. tubing as the macaroni inner string. As in other illustrations, the well is assumed to be suitably prepared for completion.

Operation 1: Fig. 3(a).

The tail pipe, packer, Lewis valve, and 4-in. tubing are assembled and run into the hole. The packer is set at the desired point, and the 4½-in. tubing landed in the tubing head. The well may be washed in partly, prior to setting the packer.

Operation 3: Figs. 3(b) and 3(c).

The macaroni string next is run, connected into the Lewis valve and hung in the tubing head. The actuating cylinder then is assembled ready for operation. The well next is washed in, down the 1¼-in. tubing; and, by means of operating the Lewis valve, through either the upper-zone-producing annulus or the lower-zone-producing annulus, as shown in Fig. 3(b) and (c).

Operation 3: Figs. 3(d) and 3(e).

After the two zones have been washed in, the well is placed on production through the two annular spaces. In the event of difficulty in inducing natural flow, the inner macaroni string may be used to assist by jetting gas down the string and into the desired annular space. The routine use of the macaroni string is for the purpose of continuously removing liquid which accumulates at the bottom of the well. The operation of the Lewis valve is controlled automatically by means of a timing device at the surface, and power for raising and lowering the tubing at set intervals is obtained from one of the annular producing passages.

Summary

As stated in the introduction, one of the main objectives of the survey was to examine multiple-zone completions already made from the point of view of savings of critical materials by means of this method of completion. In Table 1, savings in steel and cost realized by individual multiple-zone wells were shown, and these figures are summarized in Table 3.

Table 3 illustrates by areas the average savings in steel and money on a comparable basis with two standard wells. It is indicated that the weighted-average saving for the 89 cases studied is 46 per cent, or 105 tons of steel, and a reduction of 37 per cent in initial drilling cost for a multiple-zone completion as compared to two single-zone wells.

The 89 wells listed in Table 1 include not only initial multiple-zone completions, but a number of original single-zone wells which later were converted to dual producers. Serious difficulties in such cases of conversion were not reported, and this application of the method offers possibilities if there are a number of producing zones cased off.

The various procedures followed and different kinds of equipment used were described in the questionnaires. However, no attempt has been made in this paper to describe all of the alternative methods or equipment employed. Instead, generalization was attempted in order to present an over-all picture of the essentials involved, realizing that local conditions and operators' choice would dictate the final selection of both methods and equipment. Selection of type of packer, point of packer setting, type and placement of unloading valve, screen setting, casing point, etc., are flexible, and rest upon requirements of the individual well concerned and the judgment of the operator.

The questionnaires requested data on problems encountered in operating multiple-zone wells after completion had been made, and the manner in which such difficulties were overcome. Cases of trouble due to sanding up as a result of sand cutting the tubing opposite the upper perforations and paraffin difficulties were reported but, on the whole, no really major problems in producing multiple-zone wells were brought out. This may be explained partly by the fact that most of the completions are of fairly recent date, and are being produced at low allowable rates on natural flow. Perhaps during the later producing life of such wells, when water is being produced and other difficulties such as sand entering the hole become more common, the more unfavorable aspects of producing multiple-zone wells will appear.

It was hoped at the outset that it would be possible to present some reliable data on artificial-lift experience in multiple-zone wells. However, only in California and Kansas has any experience in artificial lift been accumulated. As discussed previously, California operators report considerable difficulty in artificially lifting their multiple-zone wells. On the other hand, under conditions prevailing in the Kansas wells on which data were obtained, artificial lift appears to constitute no operating difficulty. The contrasting experience in these two areas would seem to indicate that local conditions may be the governing factor in artificially lifting multiple-zone wells.

Included in the questionnaire was a request for the operators' opinion as to whether operating cost would be greater or less for multiple-zone completions. Numerous operators reported that, in their opinion, it would be less costly to operate a well completed in two zones as compared to operating two individual wells; whereas others were directly opposed to this view, on the ground that the well would require more servicing and supervision when producing from more than one zone. Because of the widely divergent answers to the question of operating cost, it appears that operators are not as yet in a position to support any conclusion on this point.

Conclusion

It will have been recognized by now that this paper is substantially a progress report of experience on multiple-zone practice accumulated by the industry to date. It is apparent that, for the most part, reliable data at present are limited to the earlier stages of multiple-zone production. Sufficient representative data on the later life of multiple-zone wells (especially during the period of artificial lift) are not as yet available to permit drawing definite conclusions as to the ultimate over-all practicability of the method. Nevertheless, on the basis of the data submitted and analyzed, it would appear possible to arrive at some general conclusions. These conclusions are outlined as follows:

1. It is indicated that the initial completion of wells in more than one producing zone can be accomplished successfully. Initial multiple completion may be expected to result in a saving of about 45 per cent in steel consumption and approximately 40 per cent in drilling costs, as compared to the drilling of two standard wells.

2. It does not follow that a successful initial multiple-zone completion ultimately will yield as satisfactory results as would single wells to the individual zones. Generally speaking, it is felt that this type of completion offers promise of being entirely satisfactory under conditions where consolidated productive formations exist and where final fluid volumes handled will come within limits of the permanent equipment in the well. On the other hand, when serious operating problems could be anticipated as a result of multiple completion, then the practicability of the method certainly would be questionable. For instance, if sand conditions necessitated screening of both zones, or if frequent workover jobs were required, the over-all result of a multiple completion might be distinctly unfavorable.

3. Insufficient data on account of limited experience under the different conditions existing preclude any firm conclusions regarding the application of artificial lift in multiple-zone wells.

4. It is indicated that the average operating costs for multiple-zone wells probably will be greater than for standard completions. This opinion is based on: (1) Operation of the well will be more difficult, especially during artificial lift; and (2) repair and workover operations will be more complicated. Perhaps the lower initial well investment, together with benefits accruing as a result of undeferred production, would offset increased production costs.

Finally, it can be said, in spite of the uncertainties involved, that the necessity under existing conditions to produce the most oil with the smallest amount of steel expenditure encourages consideration of multiple-zone completions. Most of the problems in connection with the method appear to be mechanical ones. In this early stage of its development, the practice already has commanded the attention of both operators and manufacturers. The present situation concerning critical materials reasonably may be expected to result in an accelerated development of improved equipment and more advanced methods of application.

TABLE 3—SUMMARY TABULATION

Area—	Number of multiple-zone completions	Average per-well savings of dual completion compared to two single wells: Steel, Per cent	Steel, Tons	Cost (per cent)
Gulf Coast	55	45	116	*34
East Texas	25	48	93	†41
West Texas	3	47	41	47
Kansas-Oklahoma	4	49	53	46
Arkansas-North Louisiana	2	50	157	48
		Weighted average per-well savings:		
	—	—	—	—
Total wells	89	46	105	37

*Based on 41 out of 55 wells. †Based on 19 wells out of 25. Dual completion of one of the 19 wells cost considerably more than the estimated cost of drilling two wells, on account of protracted fishing job resulting from difficulties with packer setting.

Acknowledgment

The authors wish to express their appreciation for the assistance of the membership of all topical committees on drilling and production practice in accumulating the data which were the basis for this paper.

Grateful acknowledgment is extended to all the operators who prepared questionnaires, without which active cooperation the study would not have been possible.

Especial thanks are due R. E. Bridges, of Humble Oil & Refining Co., and to W. S. Crake, Shell Oil Co., Inc., who worked with the authors in compiling and studying the data.

Methods of Preparing Butadiene

This is the second in a series of articles which will present a complete summary of the sources of butadiene as revealed by the technical literature and by the research staff of Universal Oil Products Co. A total of 38 tables of data will be presented. A list of the subjects which will be covered was published on Page 41 of last week's issue of the Journal. Successive issues will carry the remaining installments of the article.

By GUSTAV EGLOFF and GEORGE HULLA
Universal Oil Products Co., Chicago, Ill.

(PART 2)

Table 2 gives data on thermal treatment of alkenes stated to yield butadiene-1,3 among other products. It indicates that *under proper reaction conditions* ethene, butene-1, butene-2, 2-methylpropene, pentene-1, and pentene-2 are desirable stocks for thermal treatment. The given equations indicate that formation of butadiene-1,3 is dependent upon such reactions as dehydrogenation, demethanation, simultaneous demethanation plus dehydrogenation, deethanation, or deethanation plus dehydrogenation. The mechanisms of butadiene-1,3 formation from the 2,4,4-trimethylpentenes and *n*-hexadecene are quite nebulous. They presumably involve depolyberizations into 2-methylpropene and butene-1, respectively.

TABLE 2—THERMAL TREATMENT OF ALKENES

Alkenes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks (B = butadiene-1,3)	References
Ethene	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Hard glass tube	Low red heat	1(?)	B yield = ?	L. M. Norton and A. A. Noyes, Am. Chem. J. 8, 362-364 (1886).
Ethene	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Tube composition was not disclosed	600, 650, 700 750, 800, 850	1 in all cases	B yields were 0.08, 0.35, 0.73, 0.93, 0.48, and 0.096% by weight on feed at 600°, 650°, 700°, 750°, 800°, and 850°, respectively.	J. E. Zanetti, J. R. Suydam, Jr., and M. Offner, J. Am. Chem. Soc. 44, 2,036-2,041 (1922).
Ethene	$2C_2H_4 \rightarrow C_4H_6 + H_2$		600, 650, 675, 700, 750,		B was formed at all five temperatures.	E. N. Hague and R. V. Wheeler, J. Chem Soc. 1929, 378-393.
Ethene	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Quartz tube	650, 700, 750, 800	1(?)	B yields were 0.56, 0.65, 0.32, 0.26% by weight on feed, corresponding to 4.5, 1.5, 0.53, and 0.34% by weight on fully decomposed feed, at 650°, 700°, 750°, and 800°, respectively.	R. V. Wheeler and W. L. Wood, J. Chem. Soc. 1930, 1,819-1,828.
Ethene	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Quartz tube	725	0.2	B yields were 23 and 69.4% by weight on fully decomposed feed for highest contact time used and for zero contact time (infinitely slow process), respectively.	V. Schneider and P. K. Frolich, Ind. Eng. Chem. 23, 1,405-1,410 (1931).
Ethene	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Pythagoras tube (porcelain)	1,100	0.0658	B yields for contact time of 0.0007-0.0440 second were 2.7-1.5% by weight on feed, calculating to 21.8-1.7% by weight on fully decomposed feed, respectively.	H.Tropsch, C. I. Parrish, and G. Egloff, Ind. Eng. Chem. 28, 581-586 (1936).
Ethene	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Sillimanito tube	1,000	0.0658	B yield was 12.5% by weight on absolute ethene, calculating to 55% by weight on fully decomposed ethene.	Ruhrchemie A.-G. (W. Grimme, inventor), German Patent 655,616 of Jan. 25, 1938.
Ethene with nitrogen present	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Quartz tube	777, 776, 777, 776, 848, 847, 849, 848, 883, 884, 884		B yields were 4.5, 3.5, 2.3, 1.9, 3.8, 6.0, 6.8, 6.0, 7.3, 6.9, and 5.3% by weight on absolute ethene in feed, calculating to 33, 38, 47, 45, 15, 34, 36, 45, 37, 40, 47% by weight on fully decomposed ethene, for the given order of temperatures. The corresponding contact times were 1.517, 0.980, 0.481, 0.457, 1.095, 0.466, 0.454, 0.278, 0.238, 0.330, and 0.208 second.	M. Schultz and G. R. Schultz, Oel Kohle Erdoel Teer 15, 193-198, 215-220, 233-241 (1939).
Ethene + carbon monoxide + steam mixture	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Pyrex tubing (spiral)	610	1	B yield was 0.16% by weight on absolute ethene in feed.	E. A. Naragon, R. E. Burk, and H. P. Lankelma, Ind. Eng. Chem. 34, 355-358 (1942).
53.3% Ethene fraction	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Quartz tube	750	1	B yield was 13.9% by weight on absolute ethene in feed, using 11 cycles each with recovery of B and each with addition of some fresh feed.	S. Fershalov and A. Shcheglova, Kauchuk i Rezina (Caoutchouc and Rubber) 1937, No. 4, pp.11-15; Translation S-187 in June 5, 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.
78% Ethene fraction	$2C_2H_4 \rightarrow C_4H_6 + H_2$	Quartz tube containing (?) Cu gage	750	1	B yield was 10.5% by weight on absolute ethene in feed, using 5 cycles each with recovery of B.	F. N. Voronov, A. V. Voronova, F. S. Zlatopol'skii, N. A. Okhapkina, F. I. Fedoseev, F. P. Filimonov, and A. P. Shcheglova, Sintet. Kauchuk 2, No. 3, pp. 5-12 (1933); Translation S-186 in June 5, 1942, Universal Oil Products Co. Survey of Foreign Literature; F. N. Voronov and A. V. Voronova, Russian Patent 43,473 of June 30, 1935; Chem. Abs. 31. 7.448 (1937).

(Continued on next page)

TABLE 2—THERMAL TREATMENT OF ALKENES (Continued)

Alkenes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks (B = butadiene-1,3)	References
Ethene + propene fraction	Probable reactions are: $2C_2H_4 \rightarrow C_4H_6 + H_2$ $2C_2H_6 \rightarrow C_4H_6 + C_2H_6$	Quartz tube containing (?) Cu gage	750	1	B yields was 6.3% by weight on total amount of unsaturates in feed, using 5 cycles each with recovery of B.	F. N. Voronov, A. V. Voronova, F. S. Zlatopol'skii, N. A. Okhapkina, F. I. Fedoseev, F. P. Flimonov, and A. P. Shcheglova. Sintet. Kauchuk 2, No. 3, pp. 5-12 (1933); Translation S-186 in June 5, 1942, Universal Oil Products Co. Survey of Foreign Petroleum Literature.
Propene	Probable reaction is: $2C_3H_6 \rightarrow C_4H_6 + C_2H_6$	Quartz tube	725(?)	0.2	B yields were 0.0% and 6.44% by weight on fully decomposed feed for highest contact time used and for zero contact time (infinitely slow process), respectively.	V. Schneider and P. K. Frolich, Ind. Eng. Chem. 23, 1,405-1,410 (1931).
Propene	Probable reaction is: $2C_3H_6 \rightarrow C_4H_6 + C_2H_6$	Quartz tube	725	1	B yields were 2% and 4% by weight on fully decomposed feed for highest contact time used and for zero contact time (infinitely slow process), respectively.	V. Schneider and P. K. Frolich, Ind. Eng. Chem. 23, 1,405-1,410 (1931).
Propene	Probable reaction is: $2C_3H_6 \rightarrow C_4H_6 + C_2H_6$	Pythagoras tube (porcelain)	1,100	0.0658	B yields for contact time of 0.0022-0.0120 second were 1.0-3.7% by weight on feed, calculating to 3.7-5.1% by weight on fully decomposed feed, respectively.	H. Tropsch, C. I. Parrish, and G. Egloff, Ind. Eng. Chem. 28, 581-586 (1936).
Propene	Probable reaction is: $2C_3H_6 \rightarrow C_4H_6 + C_2H_6$	Quartz tube	650, 700, 750, 800	1(?)	B yields were 0.27, 0.85, 0.62, and 0.50% by weight on feed, corresponding to 2.8, 1.7, 0.71, and 0.51% by weight on fully decomposed feed, at 650°, 700°, 750°, and 800° C., respectively.	R. V. Wheeler and W. L. Wood, J. Chem. Soc. 1930, 1,819-1,828.
Propene	Probable reaction is: $2C_3H_6 \rightarrow C_4H_6 + C_2H_6$	Pythagoras tube (porcelain)	1,400	0.0658	B yields for contact time of 0.0009-0.0022 second were 5.4-0.0% by weight on feed per pass and 5.4-0.0% by weight on fully decomposed feed, respectively.	H. Tropsch, C. I. Parrish, and G. Egloff, Ind. Eng. Chem. 28, 581-586 (1936).
Propene + nitrogen mixture	Probable reaction is: $2C_3H_6 \rightarrow C_4H_6 + C_2H_6$	Quartz tube	728	1	B yield was 4.3% by weight on feed.	P. K. Frolich, R. Simard, and A. White, Ind. Eng. Chem. 22, 240-241 (1930).
Butene-1	$H_2C=CH \cdot CH_2 \cdot CH_3 \rightarrow C_4H_6 + H_2$	Quartz tube	600, 650, 700, 750	1(?)	B yields were 0.66, 1.46, 1.75, and 0.28% by weight on feed, corresponding to 1.1, 1.8, 1.8, and 0.28% by weight on fully decomposed feed, at 600°, 650°, 700° and 750° C., respectively.	R. V. Wheeler and W. L. Wood, J. Chem. Soc. 1930, 1,819-1,828.
Butene-1	$H_2C=CH \cdot CH_2 \cdot CH_3 \rightarrow C_4H_6 + H_2$	Pythagorus tube (porcelain)	1,100	0.0658	B yields for contact times of 0.0019-0.0037-0.0310 second were 9.8, 16.8, 5.3% by weight on feed, calculating to 14, 18.8, 5.6% by weight on fully decomposed feed, respectively.	H. Tropsch, C. I. Parrish, and G. Egloff, Ind. Eng. Chem. 28, 581-586 (1936).
Butene-2	$H_3C \cdot CH=CH \cdot CH_3 \rightarrow C_4H_6 + H_2$	Quartz tube	600, 650, 700, 750	1(?)	B yields were 0.58, 1.52, 1.1, and 0.53% by weight on feed, corresponding to 1.1, 1.9, 1.1, and 0.55% by weight on fully decomposed feed, at 600°, 650°, 700°, and 750° C., respectively.	R. V. Wheeler and W. L. Wood, J. Chem. Soc. 1930, 1,819-1,828.
Butene-2	$H_3C \cdot CH=CH \cdot CH_3 \rightarrow C_4H_6 + H_2$	Pythagoras tube Steam or nitrogen was used as feed diluent in several cases.	700	0.1 and 1	Pure butene-2 gave 13.4% of P by weight on feed per pass at 0.974 atm. pressure and 22.0% of B by weight on feed per pass at 0.1 atm. pressure. Butene-2 and steam mixture gave 10.7% of B by weight on absolute butene-2 feed per pass at 0.974 atm. total pressure. Butene-2 and nitrogen mixture gave 21.0% of B by weight on absolute butene-2 feed per pass at 0.995 atm. total pressure.	B. P. Fedorov, A. I. Smirnova, and P. A. Semenov, J. Applied Chem. (U.S.S.R.) 7, 1,166-1,180 (1934); Translation S-150A in Jan. 30, 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.
Butene-2	$H_3C \cdot CH=CH \cdot CH_3 \rightarrow C_4H_6 + H_2$	Copper tube	700		B yield was 18% per pass. Other tests showed 25-26% mean yield of B, based on fully decomposed feed.	E. V. Batalin, E. V. Sekretareva, and N. N. Filippovakaya, Trudy Gosudarst Opyt. Zavoda Sintet. Kauchuka, Litera B, IV. Synthetic Rubber. 1935, pp. 67-72; Chem. Abs. 31, 7,035 (1937).
Butene-2	$H_3C \cdot CH=CH \cdot CH_3 \rightarrow C_4H_6 + H_2$	Pythagoras tube (porcelain)	1,100	0.0658	B yields for contact times of 0.0012, 0.0025, 0.0110 second were 15.0, 22.5, 3.8% by weight on feed, calculating to 44.2, 33.3, 4.1% by weight on fully decomposed feed, respectively.	H. Tropsch, C. I. Parrish, and G. Egloff, Ind. Eng. Chem. 28, 581-586 (1936).

(Continued on next page)

TABLE 2—THERMAL TREATMENT OF ALKENES (Continued)

Alkenes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks (B = butadiene-1,3)	References
Butene-2	$H_3C \cdot CH = CH \cdot CH_3 \rightarrow C_4H_6 + H_2$	Copper coils for preheater and reactor	571-704	1(?)	B yields were 0.19, 0.26, 2.0, 3.2, 4.6, 0.08, 1.5, and 1.4% by weight on feed at 571°, 599°, 641°, 641°, 641°, 646°, 704°, and 704° C., corresponding to contact times of 8.9, 40.5, 2.1, 4.2, 8.5, 0.98, 0.23, and 0.31 second, respectfully. The feed had 0.5% of B, which amount was subtracted from these yields.	V. G. Moor, A. V. Frost, and L. V. Shilyaeva, J. Gen. Chem. (U.S.S.R.) 7, 818-831 (1937); Abstract 34A in Process Management Co. Foreign Literature Service (J. G. Tolpin).
"Butene"	$C_4H_8 \rightarrow C_4H_6 + H_2$		600	1 (?)	B yield = ?	G. Calingaert, J. Am. Chem. Soc. 45, 130-135 (1923).
"Butenes" and 2-methylbutene mixture obtained by dehydration of unfractionated fusel oil	$C_4H_8 \rightarrow C_4H_6 + H_2$ $C_5H_{10} \rightarrow C_5H_8 + H_2$	Electrically heated Ni or Pt wire		1 (?)	A mixture of B and 2-methylbutadiene-1,3 was obtained.	O. Nauck, German Patent 264,902 of Dec. 19, 1912; Friedlaender's Fortschritte der Teerfarbenfabrikation 11, 798-800 (1915).
2-Methylpropene	$H_2C = C(CH_3)_2 \rightarrow C_4H_6 + H_2$	Pythagoras tube (porcelain)	1,100	0.0658	B yields for contact times of 0.0013, 0.0028, 0.0110 second were 4.7, 10.5, 3.5% by weight on feed, calculating to 10.3, 14.7, 3.5% by weight on fully decomposed feed, respectively.	H. Tropsch, C. I. Parrish, and G. Egloff, Ind. Eng. Chem. 28, 581-586 (1936).
2-Methylpropene	$H_2C = C(CH_3)_2 \rightarrow C_4H_6 + H_2$	Pythagoras tube (porcelain)	1,400	0.0658	B yield for 0.0008 second contact time was 0.58% by weight on feed per pass and 0.58% by weight on fully decomposed feed.	H. Tropsch, C. I. Parrish, and G. Egloff, Ind. Eng. Chem. 28, 581-586 (1936).
Pentene-1 in the presence of steam	$H_2C = CH \cdot CH_2 \cdot CH_2 \cdot CH_3 \rightarrow C_4H_6 + CH_4$	Quartz tube	600-650	Low partial pressure of pentene-1 at both temperatures	B yield at 600° was 3.47% by weight on absolute pentene-1 feed per pass, calculating to 10.2% by weight on fully decomposed pentene-1. B yield at 650° was 8.75% by weight on absolute pentene-1 feed per pass, calculating to 12.5% by weight on fully decomposed pentene-1.	M. Mikhailov and Yu. A. Arbuzov, Compt. rend. acad. sci. U.R.S.S. [N.S.] 12, 423-426 (1936).
Pentene-2	$H_3C \cdot CH = CH \cdot CH_2 \cdot CH_3 \rightarrow C_4H_6 + CH_4$	Quartz tube	575-600		B yield at 575° was 0.23% by weight on feed per pass, calculating to 0.69% by weight on feed fully decomposed. B yield at 600° was 8% by weight on feed per pass, calculating to 12% by weight on feed fully decomposed.	J. F. Norris and R. Reuter, J. Am. Chem. Soc. 49, 2,624-2,640 (1927).
Pentene-2 in the presence of steam	$H_3C \cdot CH = CH \cdot CH_2 \cdot CH_3 \rightarrow C_4H_6 + CH_4$	Quartz tube	600-650	Low partial pressure of pentene-2 at both temperatures.	B yield at 600° was 2.37% by weight on absolute pentene-2 feed per pass, calculating to 11.3% by weight on pentene-2 fully decomposed. B yield at 650° was 9.23% by weight on absolute pentene-2 feed per pass, calculating to 15.1% by weight on pentene-2 fully decomposed.	M. Mikhailov and Yu. A. Arbuzov Compt. rend. acad. sci. U.R.S.S [N.S.] 12, 423-426.
3-Methylbutene-1	$H_2C = CH \cdot CH(CH_3)_2 \rightarrow C_4H_6 + CH_4$					I. I. Ostromyslenskii, J. Russ. Phys.-Chem. Soc. 47, 1,947-1,978 (1915); Chem. Abs. 10, 1,340-1,341 (1916).
2-Methylbutene-2	$(H_3C)_2C = CH \cdot CH_3 \rightarrow C_4H_6 + CH_4$		750 750-770	1 0.01974	B yield was 0.174% by weight on feed at 750° and 1 atm. pressure and 0.319% by weight on feed at 750°-770° and 0.01974 atm. pressure.	H. Standinger, R. Endle, and J Herold, Ber. 46, 2,466-2,477 (1913).
2-Methylbutene-2	$(H_3C)_2C = CH \cdot CH_3 \rightarrow C_4H_6 + CH_4$				See patent for details.	Russian Patent Certificate 59,220; I. I. Ostromyslenskii, J. Russ. Phys.-Chem. Soc. 47, 1,472-1,494 (1915); Translation S-152 in Feb 6, 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.
2-Methylbutene-2	$(H_3C)_2C = CH \cdot CH_3 \rightarrow C_4H_6 + CH_4$				B yield = ?	I. I. Ostromylenskii, J. Russ. Phys.-Chem. Soc. 47, 1,947-1,978 (1915); Chem. Abs. 10, 1,340-1,341 (1916).
Hexene-1 in the presence of steam	$H_2C = CH \cdot CH_2 \cdot CH_2 \cdot CH_2 \cdot CH_3 \rightarrow C_4H_6 + C_2H_4 + H_2$	Quartz tube	650-700	Low partial pressure of hexene at both temperatures	B yield at 650° was 2.04% by weight on absolute hexene-1 feed per pass, calculating to 3.2% by weight on hexene-1 fully decomposed. B yield at 700° was 6.07% by weight on absolute hexene-1 feed per pass, calculating to 6.7% by weight on hexene-1 fully decomposed.	M. Mikhailov and Yu. A. Arbuzov, Compt. rend. acad. sci. U.R.S.S. [N.S.] 12, 423-426 (1936).
3-Methylpentene-1	$H_2C = CH \cdot CH(CH_3) \cdot CH_2 \cdot CH_3 \rightarrow C_4H_6 + C_2H_6$				B yield = ?	I. I. Ostromylenskii, J. Russ. Phys.-Chem. Soc. 47, 1,947-1,978 (1915); Chem. Abs. 10, 1,340-1,341 (1916).

(Continued on next page)

TABLE 2—THERMAL TREATMENT OF ALKENES (Continued)

Alkenes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks (B = butadiene-1,3)	References
4-Methylpentene-1 in the presence of steam	$H_2C=CH\cdot CH_2\cdot CH(CH_3)_2 \rightarrow C_4H_6+CH_4+(CH_2)$ with $2CH_2\rightarrow C_2H_4$	Quartz tube	550, 600, 650	Low partial pressure of methylpentene at all 3 temperatures	B yield at 550° was 0.112% by weight on absolute methylpentene feed per pass, calculating to 0.43% by weight on methylpentene fully decomposed. B yield at 600° was 0.412% by weight on absolute methylpentene feed per pass, calculating to 0.82% by weight on methylpentene fully decomposed. B yield at 650° was 1.67% by weight on absolute methylpentene feed per pass, calculating to 2.2% by weight on methylpentene fully decomposed.	M. Mikhailov and Yu. A. Arbuzov, Compt. rend. acad. sci. U.R.S.S. [N.S.] 12, 423-426 (1936).
"Dibutene"	$C_8H_{16}\rightarrow 2C_4H_6+2H_2$	Isoprene lamp with Pt filament	500-600		B yield = ?	I. I. Ostromylenskii, J. Russ. Phys.-Chem. Soc. 47, 1,472-1,494 (1915); Translation S-152 in Feb. 6, 1942, Universal Oil Products Co. Survey of Foreign Petroleum Literature.
2,4,4-Trimethylpentene-1 and 2,4,4-trimethylpentene-2 mixture		Copper coils and quartz coils used interchangeably without presence of catalytic effects.	542, 590, 641	Not stated	B yields were 0.17-3.0, 0.43-0.48, and 0.50-1.6% by weight on feed at 542°, 590°, and 641° C., respectively, and 0.87-5.9, 2.5-3.5, and 0.82-3.7% by weight on fully decomposed feed at 542°, 590°, and 641° C., respectively.	V. G. Moor and L. V. Shilyaeva, J. Gen. Chem. (U.S.S.R.) 7, 1,779-1,786 (1937); Process Management Co. Translation 26A.
"Diamylene"	Probable reaction is: $(H_3C)_2C=C(CH_3)\cdot C(CH_3)_2\cdot CH_2\cdot CH_2\rightarrow 2C_4H_6+2CH_4$		500-600		B yield = ?	I. I. Ostromylenskii, J. Russ. Phys.-Chem. Soc. 47, 1,472-1,494 (1915); Translation S-152 in Feb. 6, 1942, Universal Oil Products Co. Survey of Foreign Petroleum Literature.
"Diamylene"	Probable reaction is: $(H_3C)_2C=C(CH_3)\cdot C(CH_3)_2\cdot CH_2\cdot CH_2\rightarrow 2C_4H_6+2CH_4$	Isoprene lamp	High temperature		B yield = ?	I. I. Ostromylenskii, J. Russ. Phys.-Chem. Soc. 47, 1,947-1,978 (1915).
n-Hexadecene	$C_{16}H_{32}\rightarrow 4C_4H_6+4H_2$	Quartz tube	500 550 600	1 1 1	Reaction not stoichiometrical. B yields = ?	H. Gault, F. A. Hessel, and Y. Altchidjian, Compt. rend. 178, 1,562-1,565 (1924); H. Gault and Y. Altchidjian, Compt. rend. 178, 2,092-2,095 (1924).

Table 3 contains data on the thermal treatment of alkadienes. The two hydrocarbons tested, 2-methylbutadiene-1,3 (i.e. isoprene) and 2,3-methylbutadiene, both gave very low yields of butadiene-1,3.

TABLE 3—THERMAL TREATMENT OF ALKADIENES

Alkadienes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks	References
2-Methylbutadiene-1,3	$H_2C=C(CH_3)\cdot CH=CH_2\rightarrow C_4H_6+(CH_2)$ with $2CH_2\rightarrow C_2H_4$	Glass tube packed with coke for the "lower" temperature conditions.	600	1	B yield was 0.18% by weight on feed.	H. Standinger, R. Endle, and J Herold, Ber. 46, 2,466-2,477 (1913)
			700	0.01974	B yield was 0.25% by weight on feed.	
		Quartz tube packed with coke for the "higher" temperature conditions.	700	1	B yield was 0.35% by weight on feed.	
			750	1	B yield was 0.29% by weight on feed.	
			800-820	1	B yield was 0.29% by weight on feed.	
2,3-Dimethylbutadiene	$H_2C=C(CH_3)\cdot(CH_3)=CH_2\rightarrow C_2H_4+C_4H_6$	Quartz tube packed with coke for the 800° conditions.	700 800	1 1	B yield at 800° was 0.029% by weight on feed.	H. Standinger, R. Endle, and J Herold, Ber. 46, 2,466-2,477 (1913).

Table 4 collates thermal treatments of cyclanes and one bicyclane, each yielding butadiene-1,3 among other products. Cyclohexane is the superior member, producing up to 60.8 per cent of butadiene-1,3 by weight upon full recycling. This is close to the theoretical yield, 64.4 per cent by weight. Ethylcyclohexane apparently yields one molecule, instead of two, of butadiene undergoing a favorable scission of the ring. The corresponding theoretical yields are 48.2 and 96.4 per cent by weight. The maximum observed yield was 19.9 per cent by weight. More work on this member and related cyclohexanes is desirable. In particular, a knowledge of the primary and secondary products would enable one to properly evaluate the roles of dehydrogenation, dealkylation, dehydrodealkenation (loss of hydrogen and alkene), and dealkanedealkenation (removal of alkane plus alkene).

TABLE 4—THERMAL TREATMENT OF CYCLANES AND BICYCLANES

Cyclanes and bicyclanes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks (B is butadiene-1,3)	References
Methylcyclobutane	$C_5H_{10}\rightarrow C_4H_6+CH_4$		High		B yield = ?	I. I. Ostromyslenskii, "Kauchuk i Ego Analogi," Moscow (1913); Translation S-210A in July 24. 1942 Universal Oil Products Co. Survey of Foreign Literature.

(Continued on next page)

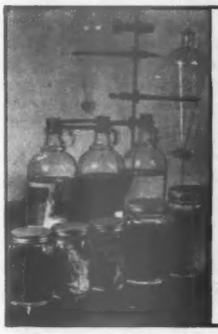
TABLE 4—THERMAL TREATMENT OF CYCLANES AND BICYCLANES (Continued)

Cyclanes and bicyclanes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks (B is butadiene-1,3)	References
Cylcopentane	$C_5H_{10} \rightarrow C_4H_6 + CH_4$	Porcelain tube with Pt gauze inside.	Dark red heat	1	B yield = ?	Farbenfabriken vorm. Friedr. Bayer & Co., German Patent 262,553 of July 11, 1913; Friedlaender's Fortschritte der Teerfarbenfabrikation 11, 822 (1915).
Methylcyclopentane	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$	Quartz vessel	850-950	0.145	Yield of C_4H_6 (B?) was 8.4% by weight on fully decomposed feed.	F. O. Rice and M. T. Murphy, J. Am. Chem. Soc. 64, 896-899 (1942)
Methylcyclopentane	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$	Probably a porcelain tube with Pt gauze inside	Dark red heat (?)	1?	B yield = ?	Farbenfabriken vorm. Friedr Bayer & Co., German Patent 262,553 of April 7, 1913; Friedlaender's Fortschritte der Teerfarbenfabrikation 11, 822 (1915).
"Dimethylcyclopentane"		Probably a porcelain tube with Pt gauze inside	Dark red heat (?)	1?	B yield = ?	Farbenfabriken vorm. Friedr. Bayer & Co., German Patent 262,553 of April 7, 1933; Friedlaender's Fortschritte der Teerfarbenfabrikation 11, 822 (1915).
Cyclohexane	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$	Electrically heated spiral of aluminum silicates. Platinum, quartz, carbon, or other "hot surfaces" can be used,	Dark red heat (?)	1?	B yield = ?	F. Hofmann, C. Coutelle, and L. Tank (assignors to Farbenfabriken vorm. Friedr. Bayer & Co.), U. S. Patent 1,050,077 of Jan. 7, 1913.
Cyclohexane	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$	Fe tube or else a porcelain tube (original article is indefinite).	600 650 700	1? 1? 1?	B yield at 650° was 7.4% by weight on feed. Also gave data for the 600° and 700° C. conditions.	A. F. Dobryanskii, E. K. Kanep, and S. V. Katsman, Transactions of the Research Plant "Khimgaz," Materials on Cracking and Chemical Treatment of Cracked Products, 2, 60-97 (1935), publ. by O.N.T.I., Leningrad (1935); Translation S-184 in May 22, 1942, Universal Oil Products Co. Survey of Foreign Petroleum Literature.
Cyclohexane	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$	Quartz tube	654	1	B yield was 13.2% by weight on fully decomposed feed.	P. K. Frolich, R. Simard, and A. White, Ind. Eng. Chem. 22, 240-241 (1930).
Cyclohexane	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$		Not stated		B yield was 36.0% by weight on feed per pass, calculating to 60.8% by weight on fully decomposed feed.	G. S. Whitby and M. Katz, Ind. Eng. Chem. 25, 1,338-1,348 (1933).
Cyclohexane	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$	Quartz tube	700	0.1?	B yield was 4.6% by weight on feed.	N. D. Zelinskii, B. M. Mikhailov, and Yu. A. Arbuzov, J. Gen. Chem. (U.S.S.R.) 4, 856-865 (1934); Compt. rend. acad. sci. U.R.S.S. [N.S.] 5, 208-212 (in German. 212) (1934); Translation S-151 in Jan. 30, 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.
Cyclohexane in the presence of steam	$C_6H_{12} \rightarrow C_4H_6 + C_2H_4 + H_2$	Quartz tube for all conditions	700 750 800	0.1? 0.1? 0.1?	B yield at 750° was 16.0% by weight on absolute cyclohexane feed per pass and 25.7% by weight on fully decomposed cyclohexane. Also gave data for the 700° and 800° C. conditions.	N. D. Zelinskii, B. M. Mikhailov, and Yu. A. Arbuzov, J. Gen. Chem. (U.S.S.R.) 4, 856-865 (1934); Compt. rend. acad. sci. U.R.S.S [N.S.] 5, 208-21 (in German, 212) (1934); Translation S-151 in Jan. 30, 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.
Methylcyclohexane	$C_7H_{14} \rightarrow C_4H_6 + CH_4 + C_2H_4$	Electrically heated spiral of aluminum silicates. Platinum quartz, carbon, or other "hot surfaces" can be used.	Dark red heat (?)	1?	B yield = ?	F. Hofmann, C. Coutelle, and L. Tank (assignors to Farbenfabriken vorm. Friedr. Bayer & Co.), U. S. Patent 1,050,077 of Jan. 7. 1913.
Methylcyclohexane	$C_7H_{14} \rightarrow C_4H_6 + CH_4 + C_2H_4$					I. I. Ostromyslenskii, J. Russ. Phys.-Chem. Soc. 47, 1,947-1,978 (1915); Chem. Abs. 10, 1,340-1,341 (1916).
Methylcyclohexane in the presence of steam	$2\,C_7H_{14} \rightarrow 2\,C_4H_6 + 2\,C_2H_6 + C_2H_4$	Quartz tube for all conditions	700 750	0.1? 0.1?	B yield at 750° was 12.3% by weight absolute methylcyclohexane feed per pass and 19.2% by weight on methylcyclohexane fully decomposed. Also gave data for the 700° conditions.	N. D. Zelinskii, B. M. Mikhailov. and Yu. A. Arbuzov, J. Gen. Chem. (U.S.S.R.) 4, 856-865 (1934) Compt. red. acad. sci. U.R.S.S [N.S.] 5, 208-212 (in German, 212) (1934); Translation S-151 in Jan 30. 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.

(Continued on next page)

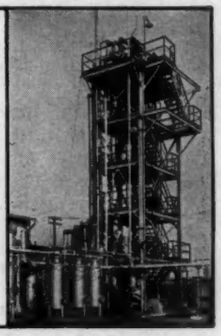
TABLE 4—THERMAL TREATMENT OF CYCLANES AND BICYCLANES (Continued)

Cyclanes and bicyclanes		Apparatus used	Temp. (°C.)	Pressure (atm.)	Remarks (B is butadiene-1,3)	References
Ethylcyclohexane in the presence of steam	$C_8H_{16} \rightarrow 2\,C_4H_6 + 2\,H_2$	Quartz tube for all conditions	700 750	0.1? 0.1?	B yield at 750° was 17.8% by weight on absolute ethylcyclohexane feed and 19.9% by weight on ethylcyclohexane fully decomposed. Also gave data for the 700° conditions.	N. D. Zelinskii, B. M. Mikhailov, and Yu. A. Arbuzov, J. Gen. Chem. (U.S.S.R.) 4, 856-865 (1934); Compt. red. acad. sci. U.R.S.S. [N.S.] 5, 208-212 (in German, 212) (1934); Translation S-151 in Jan. 30, 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.
"Dimethylcyclohexanes"		Electrically heated spiral of aluminum silicates. Platinum, quartz, carbon, or other "hot surfaces" can be used.	Dark red heat (?)	1?	B yield = ?	F. Hofmann, C. Coutelle, and L. Tank (assignors to Farbenfabriken vorm. Friedr. Bayer & Co.) U. S. Patent 1,050,077 of Jan. 7, 1913.
Allylcyclohexane			500-550 600-650	1 (all cases)	Only traces of B were obtained.	C. D. Hurd and H. T. Bollman, J. Am. Chem. Soc. 55, 699-702 (1933).
Decahydronaphthalene (i.e., decalin) in the presence of steam	$C_{10}H_{18} \rightarrow 2\,C_4H_6 + C_2H_4 + H_2$	Quartz tube for all conditions	700 750 800	0.1? (all cases)	B yield at 750° was 3.9% by weight on absolute decalin feed and 4.53% by weight on decalin fully decomposed. Also gave data for the 700° and 800° conditions.	N. D. Zelinskii, B. M. Mikhailov, and Yu. A. Arbuzov, J. Gen. Chem. (U.S.S.R.) 4, 856-865 (1934); Compt. red. acad. sci. U.R.S.S. [N.S.] 5, 208-212 (in German, 212) (1934); Translation S-151 in Jan. 30, 1942 Universal Oil Products Co. Survey of Foreign Petroleum Literature.



CHEMICALS *from* PETROLEUM

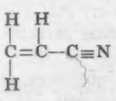
By W. T. ZIEGENHAIN



ACRYLONITRILE

FROM the position of a relatively rare chemical, this olefinic nitrogen-organic compound has sprung to a position of importance secondary only to styrene and butadiene in our present-day economy. It is employed along with butadiene in the synthesis of so-called oil-resistant rubber, known variously, depending on its source, as Hycar OR, Buna N, Perbunan, and other trade names. For this reason primarily its production has become highly important to the United States both for war and for peace uses, although the material itself is useful also as a starting material for many organic synthetics of complicated structure.

The structural formula for acrylonitrile is



Study of this formula shows that it is made up of an ethenyl radical, $CH_2{=}CH{-}$, and a cyanogen radical, $-C{\equiv}N$, combined into a straight-chain compound possessing one double-bond and one triple-bond linkage. The presence of these double and triple bonds, and the nitrogen atom also, makes this molecule highly reactive, so that it polymerizes, copolymerizes with butadiene, styrene and with numerous other unsaturated hydrocarbons and organic radicals to form an imposing list of products, many of them little known and their structure still less known.

In the manufacture of acrylonitrile a profound secrecy exists at present, regarding the methods being employed at this date for commercial operations. However, acrylonitrile may be made by reacting ethylene, as, for example, ethylene chloride, CH_2CHCl, with sodium cyanide, NaCN, according to the equation,

$$CH_2CHCl + NaCN \rightarrow CH_2CHCN + NaCl$$

Ethylene may be formed in any of the typical ways: from alcohol by dehydration, from ethane and propane gases by pyrolysis or from ethylene glycol by removal of two hydroxyl groups by hydrogenation-dehydration methods. Sodium cyanide manufacture is well known and offers no technical problems.

Acrylonitrile is a colorless liquid of 0.797 sp. gr., soluble in water, alcohol and ether, and boils at 78.5° C. (173° F.). Its low freezing point (−82° C.) simplifies its handling at low temperatures; its chemical reactivity necessitates protection from catalytic contacts during storage.

Pulley on Line Holds Tongs In More Convenient Position

On rigs using the monkey-board style of racking drill pipe, and also using the tong board for a lazy board, the lead tongs or breakout tongs hang in an awkward and unhandy place. To remedy the situation and swing the tongs nearer the center of the derrick floor, a crew on a South Louisiana rig slipped a light-boy pulley on the tong line with a sufficient length of wire attached to it to reach the leg of the derrick two girths under the tong board. The guy wire is tied to the leg to the left of the draw works facing the rotary, or the leg near the hydromatic brake to the rear of the position occupied by the lead tong man.

Mud Pump Lighting Wires Supported by Insulators

Use of some sort of metal bracket-fitting welded atop the discharge chamber of the slush pump as support for the lighting circuit wires serving that unit occasionally results in the pump becoming charged with the lighting current, due to possible short circuits. From this, serious accidents might occur.

To protect against this hazard, a company operating on the Gulf Coast stretches the wires to porcelain insulators, wired to the supporting bracket, instead of directly to the support. The wires then are looped down around the support and made fast to an insulator on the opposite side, giving full porcelain protection at all points of current-carrying wire attachment.

Record Sheet for Pipe Tallying

Drillers originally used a 1-in. by 12-in. board for tallying the joints of pipe but in recent years manufacturers of equipment have been furnishing free a more elaborate and efficient method. It includes a holder into which a cardboard sheet can be inserted. The upper half of the sheet is for the bit record and the lower half is for the pipe record. Some crews keep the record hanging close to the driller's position and all related details are written on it.

QUESTIONS ON TECHNOLOGY

By W. L. NELSON, Technical Editor

References to Diesel Engines And Their Lubrication

I want to familiarize myself with design, construction, and fuel and lubricating-oil requirements of the modern diesel engine. I would appreciate it if you or your librarian would send me a list of books or references so that I can obtain them from a library or purchase them. Such of these books as you have read, will you please indicate their contents to me?—E. R. L.

Although there are numerous references, books, etc., on the diesel engine, not many of these pertain specifically to lubrication or fuels. For this reason, it will be noted that a number of references to articles which have appeared in the trade literature are included, particularly regarding diesel engine lubrication and diesel fuels.

1. Von Bougart, "Diesel Engines." D. van Nostrand Co., New York, 1939.

2. Anderson, J. W., "Diesel Engineering," a text book, McGraw-Hill, Inc., New York, 1938.

3. Biggar, P. E., "Diesel Engines, Toronto," Macmillan Co. of Canada, Ltd., at St. Martin's House, 1936.

4. Anon., "Diesel Engineering Handbook," Diesel Publications, Inc., 192 Lexington Avenue, New York, 1935.

5. Anon., Diesel Engine Manufacturing Association, Standard Practices, 1935, Diesel Publications, Inc., 192 Lexington Avenue, New York.

6. Jones, D. L., "Diesel Engines," Norman W. Henley Publishing Co., New York, 1926.

7. Morrison, L. H., "American Diesel Engines," McGraw-Hill, Inc., New York, 1931.

8. Thomsen, T. C., "The Practice of Lubrication," McGraw-Hill Co., Inc., New York, 1926.

9. Archbutt and Deeley, "Lubrication and Lubricants," Charles Griffin & Co., Ltd., 1927.

10. Anon., "Diesel Lubrication Chief Topic at S.A.E. Convention," The Oil and Gas Journal, Page 32, January 16, 1941.

11. Bray, Moore, Jr., and Merrill, "Improvements in Lubricants Used in Diesel Engines," The Oil and Gas Journal, June 16, 1938.

12. Ramsey, R. P., "Supercharging High Speed, Four-Cycle Diesel Engines," annual meeting, Society of Automotive Engineers, Detroit, January 15, 1940.

13. Lighton and Riggs, "Observations on the Cranking of Diesel Engines," annual S.A.E. meeting, Detroit, January 15, 1940.

14. Wilkinson, P. H., "The Performance of Modern Aircraft Diesels," annual S.A.E. meeting, Detroit, January 15, 1940.

15. Zinc and Smith, "Tractor Fuels," twenty-eighth annual meeting, W.P.R.A., Wichita, Kans., April 1940.

16. Hubner, Murphy and Egloff, "A Study of Diesel Fuel Specifications," Universal Oil Products Co., Booklet No. 228, Revised to October 1939.

17. Hubner and Murphy, "The Effect of Crude Source on Diesel Fuel Quality, Part 1," National Petroleum News, Page 22, January 22, 1936.

18. Woods, George M., "Production of Premium Diesel Fuels," Petroleum Engineer, Page 58, December 1936.

19. Goodwin and Garton, "Diesel Engine Fuels From the Refiner's Point of View," Diesel Power & Diesel Transportation, November 1936.

20. Nelson, W. L., "Detonation Characteristics of Diesel Fuels," The Oil and Gas Journal, Page 42, October 2, 1942.

21. Hubner and Murphy, Part 2, National Petroleum News, Page 25, January 29, 1936.

22. Joachim, W. F., "Correlating Laboratory Diesel Fuel Tests With Engine Operation," The Oil and Gas Journal, August 19, 1937, Page 62.

23. Ainsley, W. G., "Evaluation of Diesel Fuels in Full-Scale Engines," eleventh midyear meeting, A.P.I., Tulsa, May 22, 1941.

24. Rendel, T. P., "Reasoning Behind Diesel-Fuel Specifications," The Oil and Gas Journal, October 14, 1937, Page 67.

25. Barton, C. H., "Diesel Fuel Specifications," Petroleum Times, May 23, 1936, Page 665.

26. MacGregor and Hanley, "Effect of Operating Conditions and Fuels on Diesel Engine Deposits," The Oil and Gas Journal, January 20, 1938, Page 90.

27. Baierlein, G. W., "Effect of Viscosity of the Fuel Oil on the Injection Equipment of Oil Engines," Society of Automotive Engineers annual meeting, January 15, 1940, Detroit.

28. Sailer and Manwaring, "Tractor Fuels and the Problems of Engine Designers," W.P.R.A. regional meeting, Wichita, Kans., October 31, 1941.

Benzene From Petroleum Oils and Natural Gas

Will you please tell me which refiners and gasoline plants in the Mid-Continent area manufacture benzene and what are the specifications of the benzene they can furnish for such a purpose as rubber manufacture?—P. I. J.

Much loose talk by technical men and others lead to the belief by laymen that petroleum and gas stocks contain many materials that they definitely do not contain except in perhaps exceedingly small amounts. It should somehow be made very clear that many organic chemical materials can be made from the carbon and hydrogen which constitute the bulk of petroleum by means of chemical reactions, and that in a few instances it is cheaper to start with petroleum or the particular hydrocarbons found in oils rather than to use coal, coke, hydrogen or vegetable fibers such as hays, grasses, woods, grains, etc. But, many of the chemicals that are sought (here benzene) are not, most probably, present in the petroleum, oils, or natural gas.

Scarcely any benzene occurs in naturally occurring petroleum or natural gas. One investigation[1] reports 0.0018 per cent of benzene in a natural gas. Somewhat larger amounts are present in crude oils, particularly naphthenic-base crude oils but not in amounts large enough to justify its separation.

A plant[2] in which benzene and toluene are being made as a byproduct of the decomposition of heavy cracked fuel oil, is Portland Gas & Coke Co. A yield of light oil (e.p. of 422° F.) amounting to 12.1 per cent of liquid by volume is produced but the benzene contained in the light oil probably does not exceed 35 per cent. Although this plant is operated purposely for the production of benzene and toluene, it depends upon the sale of large amounts of city gas for its main income. The gas yield is about 2,360 cu. ft. per barrel of charge stock (8.5 A.P.I. fuel oil). Knowles coke ovens are used for the decomposition process and the temperature is exceedingly high (1,300°-1,600° F.) as compared with the temperature usually employed in petroleum-processing equipment.

Cracked gasolines contain small amounts of benzene but usually not more than 2 per cent. This amount of benzene was found in a gasoline produced by catalytic aluminum chloride cracking.[3]

In order to produce benzene or other materials that are low in hydrogen (aromatic, olefins, or dienes, such as toluene, butylene, butadiene, or acetylene) it is necessary to employ higher temperatures than those now being used by the petroleum industry. This means that methods and equipments, such as those employed in the manufactured-gas industry, metal industries, or coal industry, must be employed, and that the petroleum industry will have to employ altogeher new operations and equipment if the manufacture of benzene and like materials is to be accomplished. By purely thermal processes, temperatures of 1,200°-1,650° F. are necessary, and these temperatures are well above those that are normally possible in metal equipment. Lower temperatures are possible (400°-1,000° F.) with catalysts but generally these processes require a special charge stock, such as normal hexane or cyclohexane and there is difficulty with maintenance of the catalyst.

By catalytic processes large yields can be attained. According to recordings in Ellis,[4] the following yields of benzene have been obtained in laboratory or small-scale equipment:

From hexane (Page 71, 73), 17 per cent at 460° C.
From cyclohexane (Page 93), 80 per cent at 500°-550° C.

By thermal methods alone, the yields are much smaller:

From kerosene (Page 137), perhaps 10 per cent at 700° C.
From gas oil (Page 178), 3.87 per cent at 800° C.
From cylinder oil (Page 137), about 2.5 per cent at 650° C.
From methane (Page 179), 0.27 gal. liquid per 1,000 cu. ft. at 1,150° C.
From natural gas (Page 184), about 1.82 gal. per 1,000 cu. ft. at 850° C.

Such yields are not large enough to alone justify commercial operations but along with other products the processes might be feasible.

References

1. Schrenk, Yart, and Pearce, Bur. Mines Reports of Investigations No. 3293, 1935.

2. E. L. Hall, Chem. & Met., Sept. 1942, p. 100; and The Oil and Gas Journal, p. 44, Feb. 19, 1942.

3. Dobryanskii & Zelenin, Khim. Tverdogo Topliva, 1933, 4, 606; and p. 196 of Reference 4.

4. Ellis, C., Chemistry of Petroleum Derivatives, Vol. II, Reinhold Publ. Corp., 1937.

Refinery IDEAS

. . . that save $ $ $

Heating Coil Simplifies Large-Scale Testing of Light Liquid Fractions

Samples of light liquid fractions that must be checked for vapor pressure in greater volume than normal or held at a constant temperature for subsequent testing can advantageously be kept in a water bath and at elevated temperature by means of a water bath heated by a short section of steam coil. Here the insulated section of 12-in. pipe is mounted on a stand. Closed at the bottom and containing a steam coil inside the pipe, the bath can hold sampling containers of varying sizes. Note the overflow line and large sample bomb.

Open Steam Jet and Box Keep Asphalt Moving

With winter weather, some refineries will be confronted with line problems. One operator, to keep an asphalt loading line open, took the customary means of heating the material en route. However, he does not present his solution as the most economical nor the most desirable, even though it does permit him to load asphalt on time. Essential parts include a steam line, a steam valve and an open box that can be set over the oil end of the steam pump. The steam jet is directed through the box and onto the oil cylinder to get the most out of the steam, but naturally all of the available heat in the steam is not absorbed and the waste is materially reduced by the box which is placed over the pump. This box was made from sheet iron of durable thickness and welded along the

edges to give it strength and trim appearance. No openings occur in the top of the box. The steam must find an outlet toward the front at which location some heat can be picked up by the pump rod and plunger head.

Automobile Drive Shaft Rotates Mixing Paddle

Lacking a means of rotating a paddle in a small mixing tank, a plant operator rigged up a shaft reclaimed from an obsolete Buick automobile engine. This right-angle drive included the main shaft that reaches from the rear axle to the clutch. Since the power is supplied through only one side, it was necessary to revise slightly the differential gear assembly. The main shaft is located in a vertical position enabling the operator conveniently to keep the gears well oiled. In the plant the mixing involves blending a predetermined quantity of hot asphaltic oil and a powdered filler.

Wooden-Wheeled Fire-Fighting Cart

A wooden-wheeled cart equipped to cope with ordinary small fires serves its purpose well in this refinery. Details are clearly shown in the photograph, including a box in front of the foam tank for first-aid equipment.

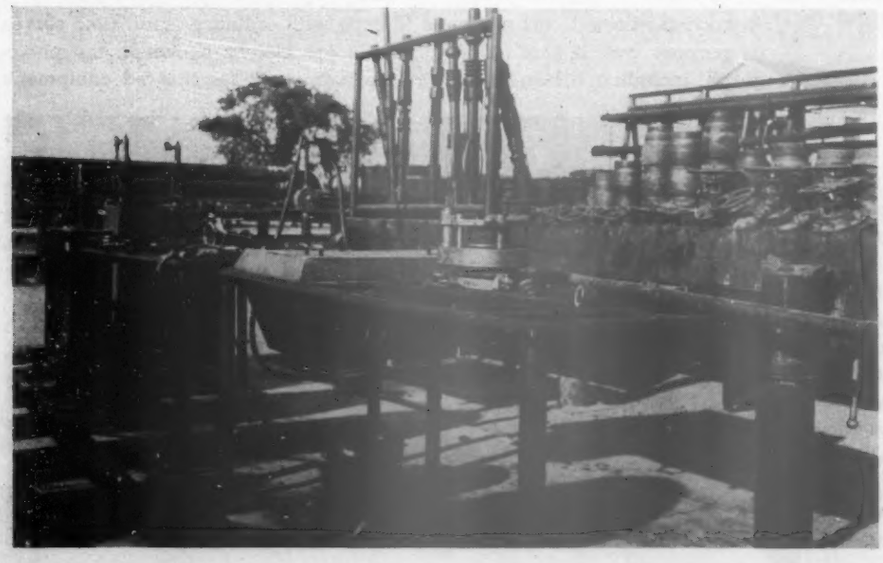
Operating Ideas

Swivel Joints Relieve Strain on Blowout Preventer Line

Instead of using a swing joint made up from paired elbows the same size of the pipe used for blowout-preventer connections, a Gulf Coast operator employs ground swing joints between the sloping run to the substructure fittings and the riser to the derrick-floor control. These joints, being designed to flex without leaking, withstand the derrick vibration and alternating expansion strains without risking the correct operation of the preventer units in time of need. Unions at the points where the leads connect to the unitized preventer control permit a quick tie-in. The leads are cut at unions and swivel joints utilized to permit riser and run to fold together and lie flat during shift of equipment.

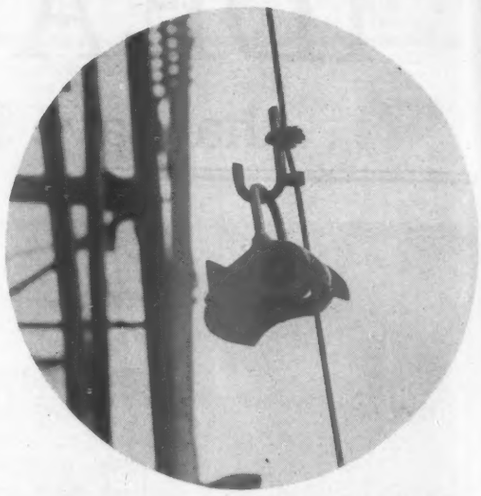
Cleaning Bench Equipped With Drain Pan

In the material yard of a major company operating in an Indiana field, a special bench has been provided for cleaning tools, fittings, valves, etc. The frame and legs are constructed of old piping. The top is a grating made from sucker rods, on the underside of which is fastened a pan for collection of the excess cleaning fluid dropping through the grating. The pan drains into a reservoir at one end of the bench. The reservoir has a bottom outlet for drawing off the accumulated fluid.



Extra Counterbalance Weight

When tong counterweights are carried below the derrick floor, it usually is difficult to obtain the exact balance necessary to relieve the floor men of strain when tonging pipe. A South Texas operator overcomes this difficulty



by means of a shallow J-hook clamped to that portion of the counterbalance line above the derrick floor. On this it is possible to hang a tong jaw or other small weight onto the line to provide the amount necessary for smooth tong handling. The amount can be varied quickly if new jaws or different pipe size make necessary a change in tong weight. When it is desired to clear the derrick floor, the extra weight may be unhooked. Then the tongs will ride to the floor. Adding to the weight of the rider will carry the tongs high.

Polished Rod Runs Through Oil

An Oklahoma operating company has equipped some of its pumping wells with a small oil box through which the polished rod operates. The box is mounted on the stuffing

box and the oil in the box reduces friction and heat on the polished rod, and eliminates considerable wear on the stuffing-box rubbers. In cold weather a mixture of kerosene is used in the reservoir.

CO$T Engineering

A WEEKLY FEATURE OF THE OIL AND GAS JOURNAL

VALUATION

NOVEMBER 12, 1942

ANALYSIS OF OIL PROPERTY DEALS

IN the purchase of properties, many "deals" are possible. These range from 100 per cent cash to an override on the property, which is a perpetual share of the working interest not subject to operating expenses but liable as a partnership with the remainder of the working interest under certain contingencies. The absolute value of an override is indefinite as the estimates of future economic production are also indefinite.

Frequently deals involve cash and a certain sum payable in oil, generally out of a fraction of the first oil produced. This affords protection to the buyer in that his oil payment may be automatically reduced if production falls short of expectancy. It also benefits the seller as the number of barrels of oil to be produced in any one year and the price of that oil cannot be predicted. He therefore pays taxes on the payments as made, whereas if he accepts notes in part payment, he will have to pay taxes on the whole sum and his taxes may be greater than the cash payment.

A property having 12 wells was appraised and the present worth of expected profits was placed at $607,291 at a price of $1 per barrel. In order to realize 100 per cent profit on the cash outlay and future capital costs on this particular property, it was estimated that $273,570 could be paid for it. There was an outstanding oil payment of $70,000 on the property.

Four possible deals were proposed for this particular property.

1. A cash amount so that the profit would be 100 per cent.

2. A cash payment of $150,000 and the balance to be paid out of one-eighth of the seven-eighths working interest, or seven sixty-fourths of all oil produced. Calculations show that $167,873 can be paid on this deal, making the total price $317,875.

3. A cash payment of $150,000 and the balance from one-fourth of seven-eighths or seven thirty-seconds of the oil. Under this plan a maximum of $265,746 could be offered or a total of $415,746. In this case, the oil payment would not start until the oil payment of $70,000 had been cleared.

4. The maximum cash bonus which could be paid to have the oil cost just 75 cents per barrel. This would amount to $391,189 and the estimated profit is 47.8 per cent on the cash outlay. This is the most that can be paid safely on a property and assumes considerable anxiety on the part of the purchaser to acquire it.

The accompanying table shows the basis of calculation for each deal. In this, it may be seen that the seller will receive the largest price, undiscounted, under deal No. 3, although if the value of the oil payment is discounted, it will be only $302,182, or less than in the case of deal Nos. 1 and 4. The buyer's profit, discounted, will be greater than in any other deal, except deal No. 2, although the expected return in terms of barrels of oil will be less than in any of them. At the same time, being out of a larger share of the oil, the risk run by the seller of not getting his full oil payment is less under this plan than under deal No. 2, while the buyer has the advantage of getting all of the working interest during the later life of the property when operating costs are higher.

Under plan No. 2 the seller's income taxes will be lower, which might impel him to take the greater risk and and accept the deal which would also give the buyer the largest return.

TABLE 1—SUMMARY OF PROPOSED TRADING DEALS

	Deal 1	Deal 2	Deal 3	Deal 4
Amount to be paid in cash (bonus)	$273,570	$150,000	$150,000	$391,389
Present worth of future development costs	60,000	60,000	60,000	60,000
TOTAL CASH INVESTMENT	$333,570	$210,000	$210,000	$451,389
Present worth of seller's working interest	$607,291	$607,291	$607,291	$607,291
Present worth of future development costs previously deducted	60,000	60,000	60,000	60,000
Present worth of seller's net future income	$667,291	$667,291	$667,291	$667,291
Present worth of oil payment	0	107,797	152,182	0
Present worth of buyer's net future income	$667,291	$559,494	$516,109	$667,291
Total cash investment	333,570	210,000	210,000	451,389
Present worth of profit	$333,721	$349,494	$305,109	$215,902
Per cent profit	100	166.4	145.3	47.8
Undiscounted value of oil payment to seller	0	$167,873	$265,746	0
Discounted value of oil payment to seller	0	107,797	152,182	0
Undiscounted value of outstanding oil obligation	$70,000	70,000	70,000	$70,000
Discounted value of outstanding oil obligation	63,413	63,413	63,413	63,413
Buyer's future net production (bbl.)	1,272,986	1,112,986	1,022,986	1,272,986
Cost per barrel when produced:				
Based on buyer's net oil only (cents)	60.25	51.77	55.33	75.00
Based on buyer's oil and all oil-payment oil purchased at $1 per barrel, royalty excluded (cents)	63.18	61.35	66.49	76.84
Based on buyer's oil plus both royalty and all oil-payment oil purchased at $1 per barrel (cents)	67.78	66.18	70.68	79.73
TOTAL PURCHASE PRICE	$273,570	$317,873	$415,746	$391,389

Sea Jeeps for Strategy

The jumping jeep now rides the waves, too. These new land and sea models . . . equally mobile on land or water . . . permit strategic movement of armed forces to effective striking points. Spicer units contribute to the performance of these "aqua cheetahs." Spicer equipment is made by mechanical craftsmen who recognize that invasion *of* America and its precious liberty can be prevented only through invasion *by* America.

Spicer Manufacturing Corporation • Toledo, Obio

39 YEARS OF Spicer SERVICE

BROWN-LIPE CLUTCHES and TRANSMISSIONS

SALISBURY FRONT and REAR AXLES

SPICER UNIVERSAL JOINTS

PARISH FRAMES STAMPINGS

Engineering Fundamentals

A WEEKLY FEATURE OF THE OIL AND GAS JOURNAL

No. 50

NOVEMBER 12, 1942

ADJUSTMENT OF SLIDE VALVES

THE cycle of operation of D-slide valves was discussed in the preceding installment of this series. As a further introduction to the subject of valve adjustment, it will be necessary to define some additional terms.

Valve lap is the linear distance that the contact edges of a valve overlap the contact edges of the cylinder ports when the valve is in mid-position. In Fig. 1, an outside-admission D-slide valve is shown in mid-position. In Fig. 2, an inside-admission piston-type valve is represented when in mid-position. In both Fig. 1 and Fig. 2,

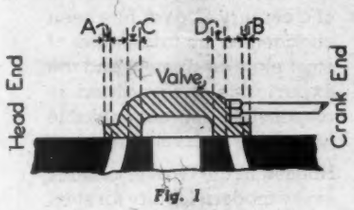


Fig. 1

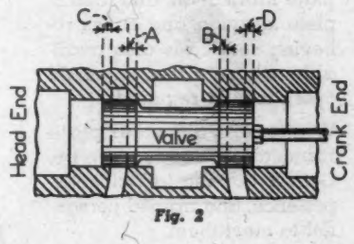


Fig. 2

the distance *A* represents the head-end steam lap of the valve, the distance *B* represents the crank-end steam lap, the distance *C* represents the head-end exhaust lap, and the distance *D* represents the crank-end exhaust lap. Lap is determined by the dimensions of the valve.

By valve lead is meant the linear distance by which a valve uncovers a cylinder port for admission of steam, when the piston is at the dead-center position. Lead is not determined by the dimensions of the valve, but is controlled by the adjustment of the valve mechanism.

The term valve travel refers to the linear distance between the two extreme positions of the valve; in other words, it is the length of the valve stroke. The valve motion is caused by the rotation of a small crank, or eccentric on the main shaft of the engine. The small crank, or eccentric, actuates the valves by means of an eccentric rod *A* (Fig. 3) hinged to a valve rod *B* (Fig. 3). Unless levers or rocker arms are used between the eccentric and the valve, the travel of the valve is equal to the diameter of the circle *C* (Fig. 3) described by the eccentric rod connection.

The angle of advance is the angle through which the eccentric must be rotated in order to move the valve a distance equal to the lap plus the lead. It is represented by the angle

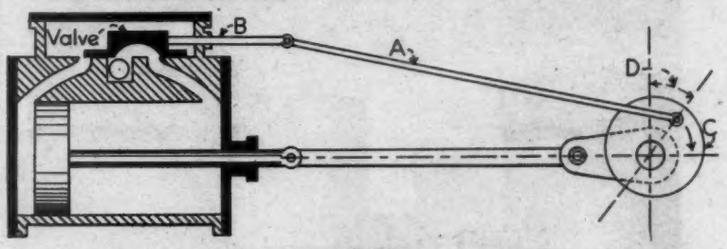


Fig. 3

D in Fig. 3 when the piston is at dead-center position.

The adjustment of D-slide valves is usually accomplished by changing either the angle of advance or by changing the lead. The angle of advance is changed by loosening the eccentric (if set-screwed to shaft) and rotating it to a new position. Ordinarily, the angle of advance cannot be changed, since the proper eccentric position is determined at the factory and the eccentric keyed to its shaft. The lead is changed by altering the length of the valve rod. Either one of two objectives may be sought in the setting of the valves, namely: (1) equal leads, or (2) equal cutoffs.

To adjust a valve for equal leads, the procedure should be as outlined below:

A. When eccentric can be moved on shaft.

1. Adjust the length of the valve rod so that the width of port openings at the two extreme positions of the valve travel will be equal to each other. This may be accomplished by loosening the eccentric on its shaft and rotating it until the valve is at one extreme end of its travel. The width of the exposed port opening is then measured. The eccentric is then rotated on the shaft until the valve is at the other extreme end of its travel, and the width of the exposed port opening measured. If the port opening widths are not the same, the valve must be moved, a distance equal to half the difference in width, toward the end of wider port opening. When the port openings are equal, this first step is accomplished.

2. Place the engine accurately on one dead center as described in Installment 48.

3. Move the eccentric on the shaft in the direction in which the engine is to run until the steam port is open by a distance equal to the lead required. Firmly fix eccentric to shaft at this position.

4. Turn the engine to the other dead-center position (see Installment 48), and measure the lead on that end. If the leads are not equal, the difference should be halved, one-half to be taken up by moving the valve on its stem and the other by moving the eccentric on its shaft.

B. When eccentric is keyed to shaft.

1. Place engine on head end dead-center position by turning flywheel. (See Installment 48.)

2. Measure the lead, or port opening, at this end.

3. Place engine on crank-end dead-center position. (See Installment 48.)

4. Measure the lead, or port opening, on crank end.

5. If the two leads are not equal, change the effective length of the valve stem by an amount equal to half the difference in the two leads, moving the valve so as to decrease the larger lead and increase the smaller.

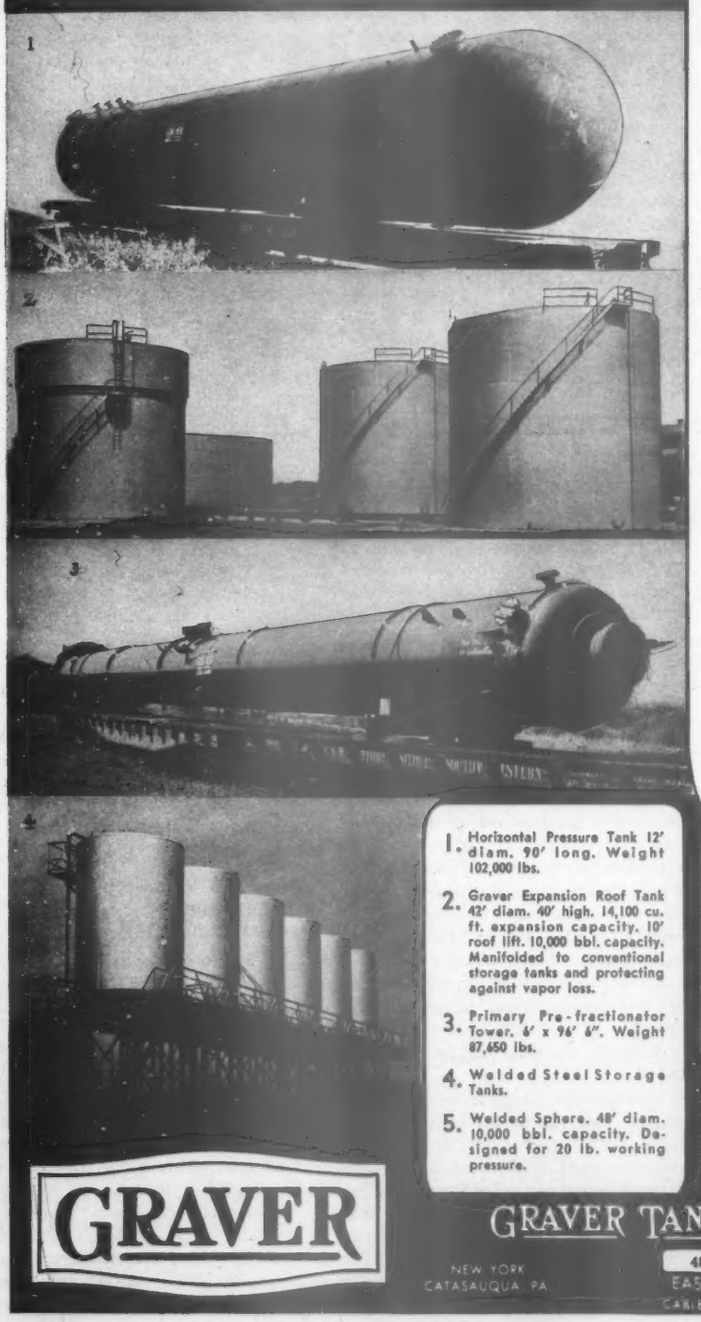
6. As a check, turn engine back to head-end dead center and measure lead. The two leads should now be equal.

7. Check operation of valves using engine indicator.

Series prepared by Glenn M. Stearns, associate professor of petroleum engineering, University of Oklahoma

STEEL PLATE FABRICATION

for the Petroleum Industry



● Throughout the industry the demand today is for more and more steel plate equipment. Towers, tanks, refinery units, stacks, process equipment—all are needed for our Victory program.

Graver is playing an important part in this gigantic undertaking, supplying many of the major oil companies with this type of equipment.

For more than three-quarters of a century Graver has been engaged in the fabrication of steel plate equipment and the experience thus gained is responsible for an enviable record of achievement.

Housed in the Graver plant is every modern facility for steel plate fabrication, and a complete x-raying and stress relieving service is also available where either of these operations is required.

Whatever your steel plate fabrication needs may be, Graver has the facilities, experience, and trained personnel to meet them.

1. Horizontal Pressure Tank 12' diam. 90' long. Weight 102,000 lbs.
2. Graver Expansion Roof Tank 42' diam. 40' high. 14,100 cu. ft. expansion capacity. 10' roof lift. 10,000 bbl. capacity. Manifolded to conventional storage tanks and protecting against vapor loss.
3. Primary Pre-fractionator Tower. 6' x 96' 6". Weight 87,650 lbs.
4. Welded Steel Storage Tanks.
5. Welded Sphere. 48' diam. 10,000 bbl. capacity. Designed for 20 lb. working pressure.

GRAVER

GRAVER TANK & MFG. CO., INC.

NEW YORK
CATASAUQUA PA

4809-29 TODD AVE.
EAST CHICAGO, IND
CABLE ADDRESS — GRATANK

CHICAGO
TULSA

WELCOME TO OUR HEADQUARTERS

Suite 1029-W, Palmer House, Chicago

23rd Annual Meeting of American Petroleum Institute, Nov. 9-12, 1942

42-26-5

Journalog

A FEATURE OF THE OIL AND GAS JOURNAL

No. 20

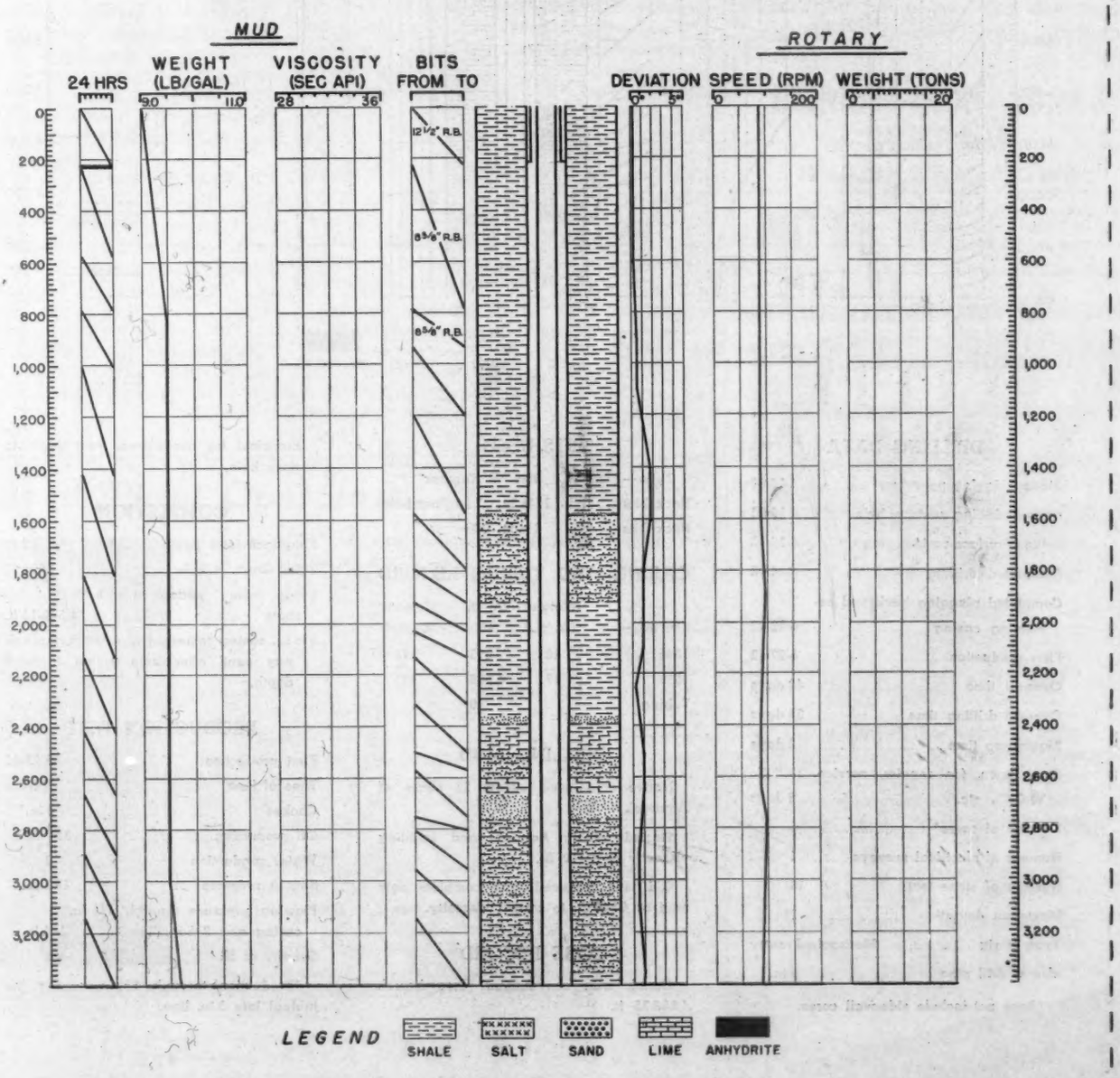
NOVEMBER 12, 1942

DEEP ROCK OIL CORP. 1 RICHARD SCHULTZ

C NW SW SE 9-22n-2e
Elevation 983 ft.

CONTRACTOR
AJAX DRILLING CO.
TULSA, OKLA.

Discovery Well, Liberty Pool, Noble County, Oklahoma

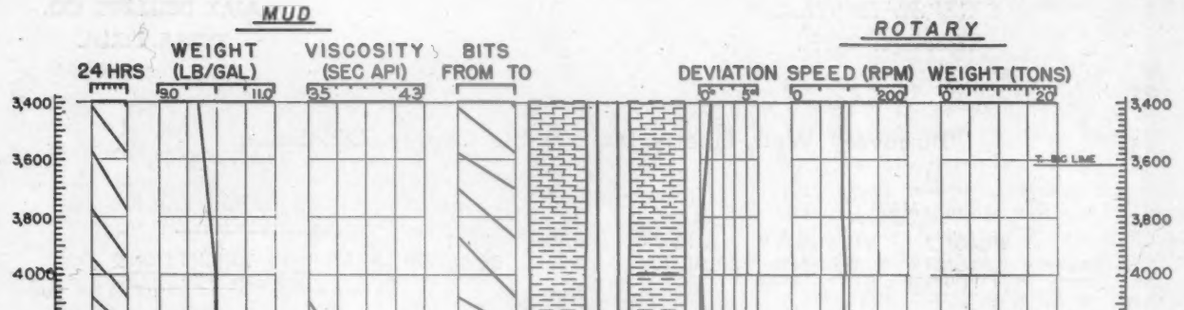


(Continued on Next Page)

Journalog

NOVEMBER 12, 1942

Discovery Well, Liberty Pool, Noble County, Oklahoma (Continued)



DRILLING DATA

Started rigging up rotary	4-16-42
Started drilling surface hole	4-18-42
Drilled surface-casing plug	4-20-42
Completed drilling	5-14-42
Completed plugging back and cementing casing	5-22-42
First production	5-27-42
Over-all time	42 days
Over-all drilling time	35 days
Rigging-up time	2 days
Shut down for repairs, service, W.O.C., etc.	8 days
Number of cores*	1
Number of electrical surveys	1
Number of slope tests	16
Maximum deviation	1¾°
Type of rig	Mechanical rotary
Size of drill pipe	4 in.

*Does not include side-wall cores.

BITS USED

Type—	Size	Number
Rock bits	12½-in.	1 (surface hole)
Rock bits	8¾-in.	38

CASING AND TUBING RECORD

Size (in.)—	Weight (lb./ft.)	Depth (ft.)	Cement (sacks)
10¾	40	215	175
5½	17	4,589	150
Tubing	....	0	.....

DRILLING MUD

Native mud used except 22 sacks of Aquagel.

Started mixing Aquagel and building viscosity at 4,100 ft.

Old mud replaced with complete new mud at 4,640 ft. to correct viscosity.

CORE RECORD

Cored with conventional core barrel, 4,668-75 ft.

Electrical log made from total depth to surface hole.

COMPLETION

Plug-back total depth	4,552 ft.
Total depth of hole	4,756 ft.
5½-in. casing* perforated with 24 shots	4,508-14 ft.

5½-in. casing cemented at 4,589 ft. through pay sand after hole drilled to total depth.

PRODUCTION TEST

First production	5-27-42
Time of flow	1 hour
Chokes	3-in.*
Oil production	250 bbl.
Water production	0
Shut-in pressure	440 lb.
Flowing pressure through 5½-in. casing and 2½-in. line	175 lb.
Gravity of oil	43°

*Production through 5½-in. casing (no tubing) into 3-in. line.

REFINERY ACTIVITY AND EXPANSION

Higher Freight Rates Threaten Oil Supplies of Midwestern Refineries

PROTESTS of Illinois and Indiana refiners against the proposed increase of freight rates applicable to shipments of Tinsley, Miss., crude were supported last week by a brief attacking the railroads' request from Leon Henderson, price administrator.

Illinois refiners cannot afford to continue in business indefinitely under constantly increasing costs and no price relief, their spokesmen contended last week before Division 2 of the Interstate Commerce Commission on the suspended tariff action. Refiners argued that they cannot withstand higher rail rates on crude petroleum from Tinsley to their plants.

Attorneys for Illinois Central Railroad replied that the proposed cancellation of special rates on shipments in 10,000-gal. tank cars, leaving only 8,000-gal. rates in effect was not really an increase but that the move was dictated by federal efforts to concentrate 10,000-gal. cars in the through movement to the East Coast. Clyde B. Aitchison, chairman of ICC, brushed the railroad's argument aside that such a purpose could be accomplished by a "car-service order" and that the question should not be decided on a rate basis.

Railroad attorneys, tracing history of rates on crude-oil movement from Tinsley to Illinois destinations, said a 24-cent per 100-lb. charge had been originally assessed 2 years ago. Later the rate was cut to 20 cents to Chicago and 17 cents to St. Elmo, Ill., because of barge and pipe-line competition. The current dual-rate system followed. The lower rates of 20 cents to Chicago and 17 cents to St. Elmo apply to minimum shipments of 10,000 gal. The higher rate of 24 cents applies to minimum shipments of 59,200 lb., or 8,000 gal. Abolishment of the rate applicable to minimum shipments of 10,000 gal. would have the practical effect of increasing cost of Tinsley crude at the Middle West refineries by 4 to 7 cents per 100 lb.

This has the effect of boosting transportation costs $500 daily for Globe Oil & Refining Co., Chicago and Lemont, Ill., and $400 daily for Allied Oil Corp.'s refinery at St. Elmo. Attorney H. D. Driscoll argued for the firms.

The firms are now paying $2,000,000 annually in oil transport costs; their charges will rise another $365,000 through this move; and with the new transportation tax, the 6 per cent increase authorized under ex parte 148, plus enforced curtailment of gasoline production to 80 per cent of

Sketches of Plant Operators . . .

P. J. SWEENEY, manager of Pan American Refining Corp.'s Texas City, Tex., refinery has literally risen from the ranks. He started his refining career in the drafting room at the Whiting, Ind., refinery of Standard Oil Co. (Indiana), in January 1916.

Successive promotions followed with Standard of Indiana through the next 13 years during which he became estimator, boilershop foreman, boilerhouse foreman, light oil treating foreman, pressure still foreman, superintendent of the light-oils department, and assistant general superintendent of the Whiting refinery.

Mr. Sweeney was relinquished to the Pan American company in 1929 when he went to New York operating headquarters as assistant general manager of manufacturing. Under his supervision at that time were refineries in Aruba, Netherlands West Indies; Hamburg, Germany; Tampico, Mexico; Destrehan, La.; Savannah, Ga., and Baltimore, Md.

Just before the sale of Pan American's foreign refineries to Standard Oil Co. (New Jersey) in 1931, Mr. Sweeney returned to Whiting to his old job as assistant general superintendent.

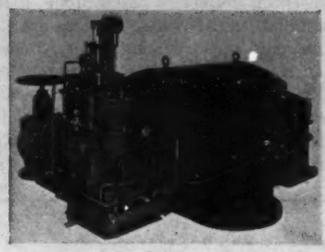
Since 1933, when Pan American Refining Corp. started construction of its Texas City refinery, Mr. Sweeney has been stationed there as manager, "realizing," he says, "the dream of every oil men to have the privilege of participating in the building of a modern petroleum manufacturing plant from the ground up."

Mr. Sweeney was born at Belvidere, Ill., completed elementary and high school work there and, in 1915, graduated from the University of Illinois. His first contact with manufacturing was with sewing machines in a year between high-school graduation and college entrance.

The adaptation of new processes, installation of increased facilities while maintaining maximum production of war materials currently permits scarce attention to Mr. Sweeney's interests away from the refinery. However, he manages to reserve some time for his 18-month-old grandson and other members of his family.

MURRAY

Steam Turbines for REFINERIES



Type UV multistage turbine. Low pressure condensing design rated 950 H.P. at 5 lbs. initial pressure, 27" vacuum. Equipped with variable speed oil pump oil relay governor, particularly adapted for hot oil pump drive.

MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

NOTE *Send this advertisement to us with your name and address for complete information.*

ESPECIALLY RECOMMENDED FOR USE IN THE

COPPER SWEETENING PROCESS

Nichols
TRIANGLE BRAND
COPPER SULPHATE

is preferred by leading refineries because of its high copper content, dependable uniformity and exceptional purity and freedom from foreign and inert matter.

99% + PURE

Quotations on request, on any quantity required. Shipments can be made from our nearest plant.

PHELPS DODGE REFINING CORP.
40 WALL STREET, NEW YORK
230 N. MICH. AVE., CHICAGO

last year's output, without a price concession on fuel oil, they cannot long remain in business, he asserted.

Price Administrator Henderson charged the road's proposal would be contrary to the economic stabilization order of President Roosevelt.

Delivery of Paratone Halted Until Reserve Is Built Up

WASHINGTON, D. C.—The curtailment of all nonessential deliveries of paratone, a lubricating-oil additive, until reserve stocks are built up to 100,000 gal., was recommended November 5 by the Office of Petroleum Coordinator. The restriction is provided by Recommendation 55.

Until this reserve supply reaches the 100,000-gal. level, paratone deliveries are to be made only to persons using this additive in the production of aviation lubricating oil, recoil oil or hydraulic oil, Deputy Coordinator Ralph K. Davies said.

Persons accepting deliveries must certify that this additive is being used in accordance with the provisions of the recommendation controlling use and delivery of paratone.

After the satisfactory reserve level has been reached, paratone deliveries may be made as usual, provided such deliveries are not made from the reserve supply, Mr. Davies explained.

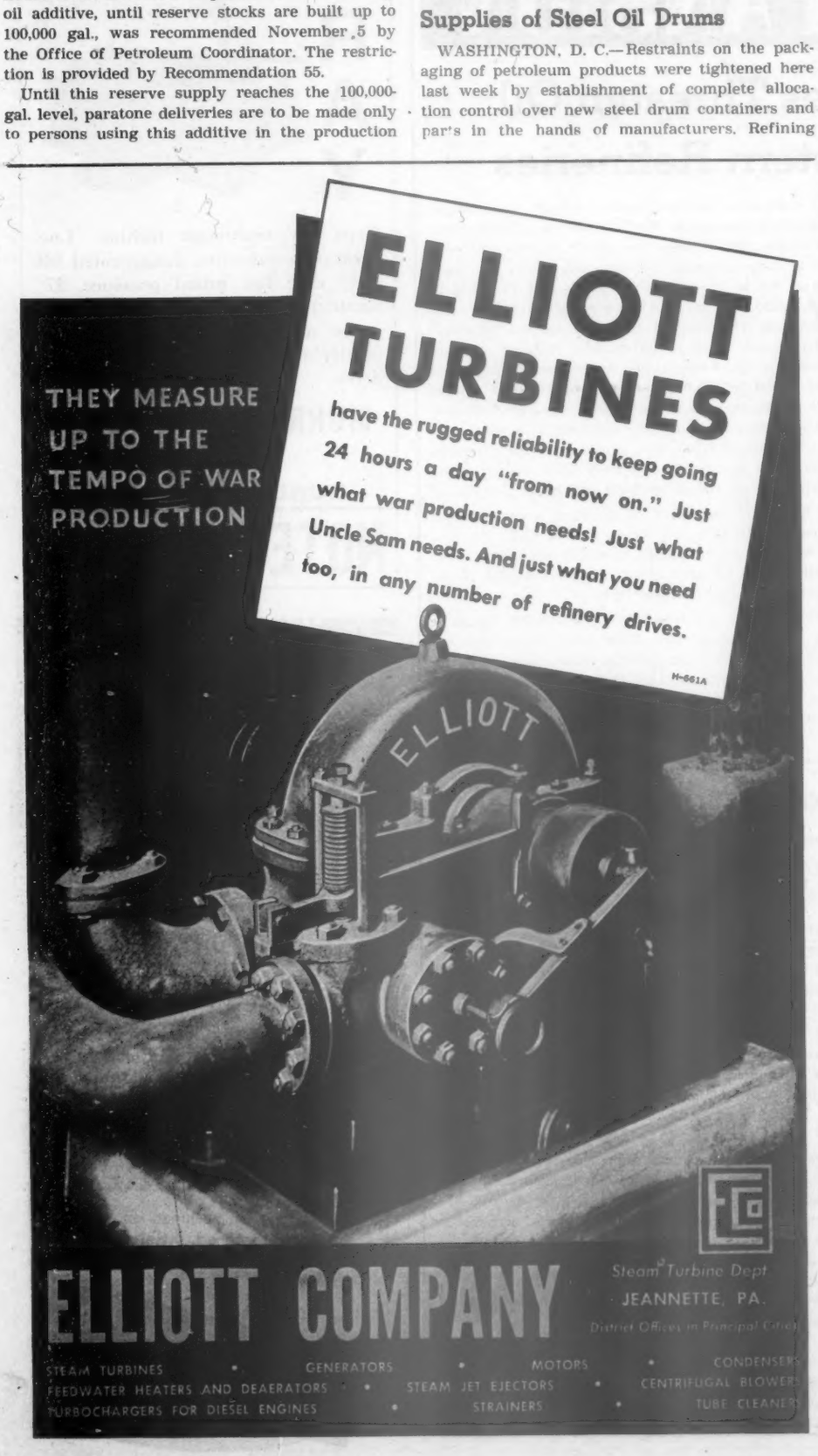
Restraints Tightened on Supplies of Steel Oil Drums

WASHINGTON, D. C.—Restraints on the packaging of petroleum products were tightened here last week by establishment of complete allocation control over new steel drum containers and parts in the hands of manufacturers. Refining companies which operate their own steel-drum manufacturing facilities are covered in the order along with commercial factories.

The order, M-255, prohibits manufacturers from selling or delivering new steel drums and parts (excepting flanges, plugs and cap seals) after November 16, without specific authorization of the director general for operations. Likewise, persons manufacturing drums for their own use are prohibited from using any drums which were not completely manufactured before November 16, unless they have similar authorization.

Authorization must be applied for by addressing a letter in duplicate to the Containers Branch, War Production Board, Washington, D. C., marked Ref: M-255. The letter should have a copy of the purchase order attached and should state what the drums are to be used for, what products are to be shipped in them, where they are to be shipped, and the use to which their contents are to be put.

An earlier order, L-197, established restrictions over the use of both new and second-hand drums, and listed products which could not be packed in steel drums. Today's action prohibits the use of new drums for packing products without authorization.


THEY MEASURE UP TO THE TEMPO OF WAR PRODUCTION
ELLIOTT TURBINES
have the rugged reliability to keep going 24 hours a day "from now on." Just what war production needs! Just what Uncle Sam needs. And just what you need too, in any number of refinery drives.
H-661A
ELLIOTT
ELLIOTT COMPANY
Steam Turbine Dept
JEANNETTE, PA.
District Offices in Principal Cities
STEAM TURBINES • GENERATORS • MOTORS • CONDENSERS
FEEDWATER HEATERS AND DEAERATORS • STEAM JET EJECTORS • CENTRIFUGAL BLOWERS
TURBOCHARGERS FOR DIESEL ENGINES • STRAINERS • TUBE CLEANERS

Refiners Asked to Increase Production of Petroleum Coke

WASHINGTON, D. C.—To increase production of raw petroleum coke, approximately 30 refineries are being called upon to raise their output of this product, Petroleum Coordinator for War Harold L. Ickes announced last week.

Raw petroleum coke is used for the manufacture of electrodes and other critical materials needed for the production of aluminum and other vital products, it was explained by Deputy Coordinator Ralph K. Davies.

The action to increase coke production was taken in OPC Recommendation 56, which states that the current deficiency in raw coke production can be partly corrected "by the fullest capacity operation of existing coking facilities in certain refineries best adapted to the production of such coke from the standpoints of availability of raw materials, character of equipment and operation, accessibility to transportation and effect on the production of war products."

Each of the refineries is directed to "eliminate or reduce the use, if any, of caustic soda or lime in connection with the production of such coke to the greatest extent possible without causing undue corrosion of the physical equipment."

Owners of the refineries presently covered by this recommendation are Cities Service Oil Co., Continental Oil Co., Sinclair Refining Co., Gulf Oil Corp., Shell Oil Co., Inc., Standard Oil Co. (Indiana), Standard Oil Co. of Ohio, Texas Co., Kendall Refining Co., Utah Oil Refining Co., Union Oil Co. of California, Magnolia Petroleum Co., and Socony-Vacuum Oil Co., Inc.

Minimum Specifications Set Up for Eastern Supplies

WASHINGTON, D. C.—The Office of Petroleum Coordinator last week prescribed minimum specifications on four principal oil products pooled for and after shipment to the East Coast to implement Directive 59.

Detailed specifications for the guidance of all refiners and distributors subject to provisions of Directive 59 were issued over the signature of P. M. Robinson, acting director of refining for OPC.

The complete memorandum follows:

"Pursuant to S 1510.31 of Petroleum Directive 59 issued by the Petroleum Coordinator for War, and for the purposes therein stated, the Director

of Refining hereby establishes, until further notice, the following minimum specifications for each of the principal petroleum products referred to in said directive.

1. *Motor gasoline.*—There shall be two grades of motor gasoline, regular (otherwise called housebrand) and premium.

(*a*) *Regular or housebrand gasoline.*—Regular or housebrand gasoline shall conform to certain minimum requirements of U. S. Army Specification No. 2-114, issued April 30, 1942, and any amendments thereto that may be issued from time to time, as follows: Section B—Grades; subsection C-1—Material and workmanship; Section E—Detailed requirements (whenever applicable geographically); Section F—Methods of sampling, inspection, and tests.

(*b*) *Premium gasoline.*—Premium gasoline shall conform to certain minimum requirements of the U. S. Army Specification 2-103A, issued March 2, 1942, and any amendments thereto that may be issued from time to time, as follows: Section B—Grades; Subsection C-1—Material and workmanship; Section E—Detailed requirements (whenever applicable geographically); Section F—Methods of sampling, inspection, and tests.

2. *Kerosene.*—Kerosene shall conform to certain minimum requirements of the Federal Specifications VV-K-211a, approved April 9, 1941, and any amendments thereto that may be issued from time to time, as follows: Section B—Grades; Section D—General requirements; Section F—Methods of sampling, inspection, and tests.

3. *Fuel oils.*—Distillate fuel oils (including gas oils) and residual fuel oils shall conform to certain minimum requirements of the corresponding fuel oil set forth in "Fuel Oils" (Fifth Edition), Commercial Standard CS-12-40, effective January 5, 1940, and any respective amendments thereto that may be issued from time to time, as follows: Section 1—Scope; Section 2—General requirements; Section 3—Detail requirements (whenever applicable geographically); Sections 5 to 16, inclusive (whichever are respectively applicable) methods of test.

General.—The minimum specifications set forth in Parts 1, 2, and 3 above shall apply only to those principal petroleum products imported into or produced in District 1 pursuant to the provisions of said directive. Nothing herein contained shall require any change or action in conflict with any federal, state, or local law, order or regulation, or any directive of any federal war agency, or waive any provision of any other specification not inconsistent herewith, or apply to any principal petroleum product of a different specification ordered by the U. S. Army, Navy, Maritime Commission, or Office of Lend-Lease Administration.

Michigan Refinery Sold To Tulsa Firm

STARK, Mich.—The Titan Oil Co.'s Dubbs refinery plant here has been purchased by Sonken-Galamba Supply Co., of Tulsa, according to W. C. Berry, president of the Tulsa firm. The plant includes a 4,000-bbl. topping plant a 2,000-bbl. visbreaker plant and a 500-bbl. asphalt plant. The plant also features a complete instrument board, electric-eye control, pump house complete with explosionproof motor-driven centrifugal pumps and 18 heat exchangers.

Imperial's Sarnia Refinery Starts Delivery of Still Gases

SARNIA Ont.—Deliveries of refinery-still gas from the Imperial Oil, Ltd., refinery here to the Union Gas Co. of Canada were started late in October following completion of a $1,000,000 purification and processing plant which had been under construction for nearly a year.

GASOLINE
DEEP-ROCK
MOTOR OILS

Buy War Bonds for Victory

DEEP ROCK OIL CORPORATION
TULSA, OKLAHOMA

Helmerich & Payne, Inc.

Philtower

Tulsa -:- -:- -:- -:- Oklahoma

Greetings . . .

to the American Petroleum Institute, a cordial welcome to Chicago and best wishes for a successful and enjoyable convention.

STANDARD OIL COMPANY (INDIANA)

Pipe-Line Activity

W.E.P. Starts Work On Feeder Lines

Construction of feeder lines for the Longview, Tex., terminal of War Emergency Pipelines, Inc., will start this week. These lines will belong to two systems. One will bring No. 2 heating oil from the Pan American Pipe Line Co., Shell Pipe Line Corp. and Sun-Yount Lee trunk lines. According to present plans, the other system will bring crude oil from trunk lines of Magnolia Pipe Line Co., Texas Empire Co. of Texas (handling shipments for Cities Service, Texas Co. and Tide Water Associated interests) as well as bring crude from Sinclair operations centering at the Moncrief lease in East Texas. Welding of feeder lines will begin as soon as the firing line of Williams Brothers Corp, is moved from the location where it has been engaged in completing the southern section of the Texas-Illinois leg of the 24-in. crude oil line.

At the beginning of this week, more than 405 miles of 24-in. pipe had been completed between Longview and Norris City in spite of bad weather which prevailed in the northern territory. Building of station foundations has started. Trackage is being laid at Norris City to expedite rail shipments of crude to be moved eastward. Acme Railroad Construction Co. was awarded contract for installing about 10 miles of railway tracks at Norris City.

Dismantling and construction of 39 oil tanks of 80,000-bbl. capacity has been divided equally among Steel Tank Construction Co., Pittsburgh-Des Moines Iron and Steel Co., and Graver Tank & Manufacturing Co.

Pipe Is Shipped for Loops Of Stanolind in North Texas

After several weeks delay, 12 carloads of pipe have been shipped from the mill for laying two loops for Stanolind Pipe Line Co. in the Nocona-Graford area of North Texas. Provision for laying these loops consisting of 54 miles of 12-in. was made in the early plans for Project 1, of the OPC program, for increasing capacity of present trunk lines between Texas and the East Coast. The Stanolind loops will increase capacity of the line delivering from Graford, Tex., to Healdton, Okla., from 20,000 to 30,000 bbl. daily. This 10,000-bbl. increase will serve an important purpose in moving more crude oil northward out of Texas which is much needed for the national program. The project is financed by Stanolind Pipe Line Co.

The contractor, Jones & Brooks, has a field office at Nocona, Tex. At present right-of-way is being cleared. Laying of pipe will start as soon as sufficient shipments have been received.

Employes of Tide Water Associated Oil Co.'s southern California pipe-line department receive U. S. Treasury Certificate and "T" Pennant. In the foreground are Earl Gilfillan, supervisor of pipe lines; D. D. Stark, superintendent of Watson refinery; Frank E. Coyle, superintendent of southern California pipe lines, and Vaugh Boyington, representing the southern California administrator's department of war bonds and savings stamps office

Lone Star Gas Is Laying 82 Miles in East Texas

Plans for laying 82 miles of line to bring additional gas from the East Texas field to meet peak demands have been completed; construction is scheduled to start this month, according to R. Vandercook, pipe-line superintendent, Lone Star Gas Co. Four lines will be installed by contracting companies.

Men directing construction for the company are: Julian L. Foster, general superintendent and chief engineer; Mr. Vandercook, and Luther Tolbert, assistant pipe-line superintendent.

Thirty-seven miles of 18-in. pipe will start at the junction of lines O and S southwest of Dallas between Lancaster and Duncanville, Tex., and continue southeast to the Dixon farm, about 9½ miles east of Alma in Ellis County, Texas. At these two points it will join the 20-in. line S, then immediately parallel it for 37 miles. A 117-mile line extends from Irving and ties into the East Texas gas field at Cayuga, Long Lake and Grapeland, Tex.

Pipe for the project has been made available by taking up line O between Gordon and Granbury, a distance of 37 miles. The pipe has been hauled by truck to four points on the right-of-way where it will be cleaned.

Another line will start near the junction of lines L8A and L8AE, about 6 miles west of Dew,

Trenching it's Buckeyes

They dig trench in any soil with maximum speed. The tough, compact Model 11, smallest of the Buckeye Pipeliners, for small crude, gasoline and natural gas lines. Model 12 for medium lines; Models 32 and 48 for main lines.

BUCKEYE TRACTION DITCHER COMPANY
Findlay, Ohio
Built by Buckeye
TRENCHERS, SHOVELS, CRANES
BACKFILLERS, TRACTOR EQUIPMENT

RECONDITION YOUR PIPE
This Inexpensive Way

For those sections of your pipe line where corrosion is severe, recondition with cold, hand applied, NO-OX-ID coatings. They are inexpensive to apply and give lasting protection. NO-OX-ID not only excludes moisture and other corrosion accelerators but stops all underfilm corrosion. Dearborn Chemical Company, Dept. E, 310 S. Michigan Ave., Chicago.

NO-OX-ID
IRON-OX-RUST
TRADE MARK
Rust Preventive Pipe Coatings

JAMES ANDERSON COMPANY
ENGINEERS and SURVEYORS
Established in 1893
available
to
the oil and gas industry
for the
surveying of extensive rights-of-way
anywhere

JAMES ANDERSON COMPANY
290 East Deerpath
LAKE FOREST, ILLINOIS

CHAS. MARTIN & COMPANY
Inspectors of Petroleum
Approved and Licensed by New York Produce Exchange
GAUGING • SAMPLING AND TESTING • TANK STRAPPING
BARGE CALIBRATION • CRUDE CLASSIFICATION • GAS ANALYSIS
1215 Dumble Street, Houston, Texas
Laboratories located at:
Houston, Texas
Corpus Christi, Texas
New Orleans, La.
Jennings, La.
Elizabeth, New Jersey
New York Office: Produce Exchange Annex
Branch offices at all oil ports.

and continue 31⅛ miles west to Groesbeck, Tex. It will contain 28 miles of 12-in. and 3⅛ miles of 10-in. pipe, and tie into and parallel the Long Lake-Waco 12-in. line. Pipe taken up from lines near San Angelo and Ranger, Tex., will be trucked to Groesbeck, Mexia and Teague, Tex., for cleaning and stringing on the right-of-way. The line will cross the Navasota River east of Groesbeck.

Starting 12 miles west of Dew at a point on line L8A, 4 miles of 8-in. pipe will be laid to Teague, Tex., where it will connect L8A with line M-18, adding another outlet for East Texas gas to enter the company's interconnected pipe-line system. Pipe for this line has been taken up from line RF in Coleman County, Texas.

Another line, totaling 9.7 miles of 8-in. pipe, will be laid. It will extend from a point just north of Groesbeck, Tex., parallel line M-11-7 and terminate north of Groesbeck.

Hearing Is Set for Somerset Line Removal

The Texas Railroad Commission has called a hearing to be held here November 17 on application of Dunigan Tool & Supply Co. to remove 15 miles of pipe line between Someret and San Antonio, Tex.

I.C.C. Reports 128,337 Miles Of Petroleum Pipe Lines

The Interstate Commerce Commission reported today that 128,337 miles of petroleum pipe line were in operation in the United States in 1941, of which 74,823 miles were trunk lines and 53,514 miles gathering lines. In 1936 there were 115,038 miles of pipe lines in the nation, which included 62,278 miles of trunk lines and 52,760 miles of gathering lines. The ICC based its report on data submitted by companies which control 82.15 per cent of the pipe lines in the country.

Within the past year several large pipe lines have been built to displace tanker shipments. These include such lines as the 236-mile Portland-Montreal crude-oil line and the 450-mile Southeastern products line. The Plantation products line is now being extended so that pipe-line shipments from as far southwest as Houston, Tex., may be delivered at Richmond, Va. The present War Emergency Pipelines, Inc., 1,500-mile 24-in. crude line will probably be paralleled by a products line.

Pipe-Line Personalities . . . Elmer F. Schmidt

ELMER F. SCHMIDT, vice president and operating manager, Lone Star Gas Co., was born at Binghamton, N. Y. He had several years of experience with natural-gas systems in eastern fields before he joined the Lone Star Gas organization in 1918. In his present position he has executive supervision over production operations as well as the network of pipe lines in the transmission system which includes more than 4,400 miles of lines of diameters between 2-in. and 24-in., and 19 compressor stations. In addition 95 miles of line has been leased to the federal Government.

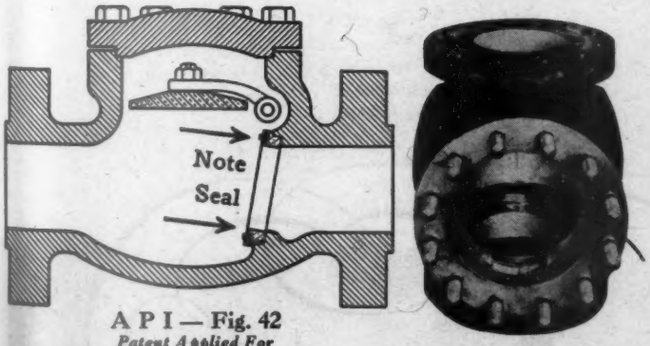
His work in the natural-gas industry after receiving a civil engineering degree from Cornell University in 1912, was with the engineering department of Ohio Fuel Supply Co., at Charleston, W. Va., where he remained until 1913. That year he joined the staff of Northwestern Ohio Natural Gas Co., at Toledo, Ohio. The following year he was with Fayette County Gas Co., at Uniontown, Pa. In 1915 he took a position in the engineering department of Ohio Fuel Supply Co., at Columbus, Ohio. Two years later he was transferred to the gas-measurement department of that company.

During the time he was engaged in measurement work he made significant contributions to the development of an orifice meter recording mercury differential gage for high-pressure gas measurement and the gas-density balance used widely in determining specific gravity of natural gas. Research conducted in that period was important in devising methods adopted by the industry for dependable high-pressure natural-gas measurements.

When he joined Lone Star Gas Co., Mr. Schmidt was put in charge of the gas-measurement department. In 1919 he was promoted to chief engineer and he was made general superintendent in 1920. He was elected to the board of directors in 1935 and became vice president with his present responsibilities.

WHEATLEY SYNTHETIC RUBBER SEAL CHECK VALVE

(FULL OPENING HORIZONTAL SWING CHECK VALVE)



API — Fig. 42
Patent Applied For

These valves are identical with the standard Wheatley check valves except they are equipped with the Wheatley Synthetic Seal—a synthetic rubber ring dovetailed and fitted into a removable bronze seat also dovetailed to accept this rubber ring. When the bronze clapper falls against this rubber, a perfect seal is formed regardless of what irregularities have deposited on the seat or in the fluid, such as sand, scale and cuttings which ordinarily would cut a hard-surfaced seat completely out, with aid of pressure, of course.

Preferred by the United States Engineers on projects handling high octane gasoline. Write for Bulletin No. J-42.

Made in sizes 2″ to 24″ in pressures from 125 lbs. to 2000 lbs. Flanged and screwed ends or both; all series, Ludlow, and special drillings. Steel, iron and bronze.

DEFINITE ADVANTAGES OF THE ONE AND ONLY SYNTHETICALLY SEALED CHECK VALVE

- Removable bronze seat ring, into which the rubber ring is inserted, can be replaced by the standard metal to metal seat, if desired.
- The rubber ring, itself, can be replaced from our stock and no additional work is necessary for installation.
- The rubber ring conforms to all deposits and obstacles and makes it possible for this valve to seal under the worst conditions.
- Specified for gathering lines. Less pressure required for positive seal than with the metal to metal seal which depends entirely on pressure.
- Absolutely silent in operation. Ideal for refineries and pumping stations where the slapping of metal check valve clappers is annoying.
- Seals regardless of viscosity. Operates equally well on kerosene or crude.
- Corrosion and rust proof.
- Under severe tests for two years without complaint.
- No additional charge for Synthetic Seal feature.

BUY WHEATLEY SYNTHETIC SEAL VALVES

4″ Full Opening Horizontal Swing Check Valve with Synthetic Rubber Seals, 500 lbs. W.P., 1000 lb. Test, Semi-steel body, flanged both ends, series 30, f.o.b. destination, **$26.50** net to consumer. In stock for immediate shipment on ratings as low as A-8.

WHEATLEY BROS. PUMP & VALVE MFRS.

TULSA, OKLAHOMA Phone 5-2176

The "SECRET"

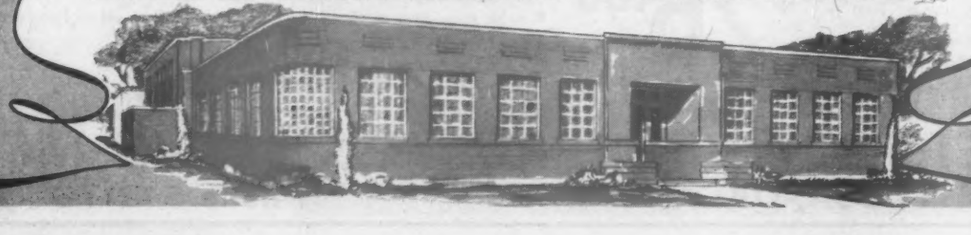
of effective exploration work:

———is found in the simple formula of using experienced crews, giving them thorough methods of procedure and improved instruments to use . . . plus careful supervision.

IXC

Independent

EXPLORATION COMPANY



★ HOUSTON

★ TEXAS

FIELD DEVELOPMENTS...

HIGHLIGHTS FROM THE WEEK'S NEWS—

As the year 1942 enters its final 2 months, it appears as if the OPC estimate of 19,000 wells to be drilled during the year will prove fairly accurate. Many causes for the decline from 32,140 wells in 1941 have been advanced, with OPC itself vieing with OPA for the position of greatest importance. Another factor, not generally considered, may eventually prove most important of all, namely a decline in the number of locations that can be drilled. The effects of OPC and OPA are temporary. They can be removed easily by legislation or by administrative act. The decline in locations cannot be so affected.

There is little doubt but that an increase in price would stimulate drilling. On the basis of probability, the more wildcats that are drilled, the greater will be the number of discoveries. A further extension of this reasoning to cover oil reserves does not necessarily follow. Fields of great size are found so seldom that it is impossible to correlate their frequency with that of all discoveries. Recent discoveries have been more important from the standpoint of new areas opened up than from that of additions to reserves.

A case in point is the new pool opened up in southeastern Wyoming in the north end of the Denver basin. Production has been found around the northern rim of the basin and on the Greasewood dome within the basin. The new pool, 42 miles north of the Wellington field in Colorado, lies in the foothills belt and marks a major extension. Added to this is the fact that the pay is new for this sector, the Lakota while the Colorado fields produce from the Muddy and Dakota. Unlike many Rocky Mountain structures, Horse Creek had no surface expression, having been found by gravimeter survey.

Following normal practice, other wildcats started up immediately following the discovery.

The fact that a successful wildcat in any sector is an important factor in stimulating drilling is indicated by the completion table on this page. Some areas show much less than the general decline in activity. These do not have any particular advantage, either of price or of freedom from the restrictions of M-68. They are the areas in which new fields have been developed and in which drilling was possible. Michigan, Kansas, the Texas Gulf Coast (particularly Jackson County), the Rocky Mountain districts and New Mexico have all seen considerable drilling based on discoveries. It is probable that without OPC, there would still have been a sharp drop in drilling this year based on the lack of important new fields. The discovery trend has been down for 4 years and a price increase might not quickly reverse it.

MONTANA: The recent Madison lime discovery well northwest of Cut Bank has shut off water and is now flowing. Further activity is starting (p. 261).

OHIO: Two gas fields were extended in Medina and Guernsey counties (p. 254).

CALIFORNIA: Following issuance of a permit to drill a deep test in the Gilmore Island area of Los Angeles, search is being made for other favorable locations within the city limits. Drilling in the shallow heavy-crude fields around the edge of the San Joaquin Valley is increasing with some good producers reported weekly (p. 257).

EAST TEXAS: The Woodbine sand has yielded a good gas flow with some distillate in the Grapeland area of Houston County. Several wildcats are nearing their objectives in Lower Cretaceous and Jurassic horizons (p. 255).

WEST TEXAS: Sweet gas was found in a sandy lime pay 10 miles northwest of the Page field in Sutton County. The Tubb pay in the Embar field was extended 1¼ miles north. Sulfur water was found in the Ellenburger in a wildcat 12 miles northwest of the Embar field. Ward County's first Tubb production was found in the Monahans field (p. 251).

LOUISIANA GULF COAST: Following the extinguishing of a fire which burned for several weeks, Union Sulphur's Acadia Parish wildcat is flowing distillate at 10,447 ft. The Bayou Couba discovery well completed last September has gone dead after beginning to make salt water (p. 251).

CANADA: The Fort Norman field is second among the list of Canadian producing areas, being exceeded only by Turner Valley. Production is still small, however, pending development of transportation facilities. Experiments are being conducted in Turner Valley to determine optimum flow conditions. A $12,000,000 processing plant for the Athabaska tar sands has been outlined. An output of 10,000 bbl. daily is planned (p. 260).

KANSAS: Arbuckle production is in prospect from two wildcats, one west of the Drach pool in Stafford County and the other east of the old Fairport field in Russell County (p. 256).

ILLINOIS: Two tests are showing oil in a hitherto disappointing section of Clay County, one east of Iola and the other southwest of Flora (p. 252).

SOUTHWEST TEXAS: A large gas well has opened a new producing area in the Sarco Creek area of Goliad County. South of the Kohler field, Duval County, an outpost well was pumping oil and salt water (p. 255).

ARKANSAS: A new gas field has been opened in Pope County in the Arkansas River Valley sector (p. 259).

TEXAS GULF COAST: Ohio's Austin County wildcat flowed distillate with some water on a test at 9,180 ft. (p. 256).

NORTH CENTRAL TEXAS: A wildcat northwest of Illinois Bend, Montague County, plugged back to Strawn sands after finding the Ellenburger dry and is swabbing oil. The Watson field in Clay County has 11 active operations (p. 253).

COMPLETIONS IN ALL FIELDS . . .

(Week Ended November 7, 1942)

	Oil	Gas	Dry	Total	Footage	Ttl. comp. to date 1942	Ttl. comp. to date 1941
N. Y., Pa., and W. Va.	57	13	2	72	138,705	3,042	5,117
Ohio	5	17	20	42	97,186	1,005	1,466
Indiana	3	0	5	8	12,804	310	443
Kentucky	5	1	1	7	13,010	226	580
Illinois	33	0	14	47	118,391	1,595	3,170
Michigan	6	2	10	18	40,391	616	776
Kansas	13	2	15	30	98,753	1,362	1,853
Nebraska	0	0	0	0	0	31	75
Missouri, Iowa	0	0	0	0	0	13	33
Oklahoma	6	1	6	13	44,291	1,019	1,614
Texas:							
North Central Texas	9	0	11	20	78,185	972	2,460
West Texas	13	0	3	16	75,201	1,169	1,948
Texas Panhandle	3	1	1	5	15,341	317	580
Eastern Texas	5	3	5	13	74,929	359	917
Texas Gulf Coast	4	0	3	7	46,316	608	936
Southwest Texas	11	2	8	21	94,739	927	1,620
Total Texas	45	6	31	82	384,711	4,352	8,461
North Louisiana	6	2	2	10	29,435	425	666
Louisiana Gulf Coast	0	0	1	1	6,023	422	734
Total Louisiana	6	2	3	11	35,458	847	1,400
Arkansas	1	1	2	4	21,341	156	172
Mississippi and Southeast	0	0	0	0	0	67	238
Montana	0	0	0	0	0	178	255
Wyoming	2	0	0	2	10,917	96	155
Colorado, Utah	0	0	0	0	0	20	27
New Mexico	2	0	1	3	10,314	229	239
California	34	0	1	35	89,987	664	953
Total United States	218	45	111	374	1,028,789	15,827	27,027
Total previous week	183	40	97	320			
Week ended Nov. 8, 1941	398	67	140	605			

Oklahoma City Production Is Bolstered By Active Drilling

By NEIL WILLIAMS

THE once highly prolific Wilcox sand area of the Oklahoma City field, Oklahoma, in which new development long since has been considered at an end, is undergoing a redrilling program that promises not only to forestall the premature abandonment of many old leases and wells but also to become an important factor in maintaining or increasing the current productivity of the field. The work is of particular significance at this time in view of the position which this field holds in helping to meet the increased demand for oil from the Mid-Continent district.

Night scene in Oklahoma City field showing some of the redrilling operations now under way

Most of the redrilling in this field is caused by the receding fluid level in the producing horizon, a phenomenon which lately has become fairly definitely established. First recognition of its existence came late in 1939, since which time, largely on the strength of this theory, 72 wells, excluding old holes redrilled, have been completed within the limits of the Wilcox sand area. Of those wells 68 have been oil producers, with an average production of 325,000 bbl., as of September 1.

Prior to 1940, the last drilling play occurred in 1937, when it was supposed that the field, so far as the Wilcox zone was concerned, was completely drilled up and that all the remaining production would be recovered by secondary methods only. That play quickly subsided, and in 1938 only three wells were drilled, one of these being dry. Only two wells, one a dry hole and the other a weak producer, were completed in 1939.

In 1940, following conception of the theory of reducing fluid level, 19 wells, all producers, were drilled. Thirty-eight wells, of which 37 were producers, were drilled in 1941. This year, despite restrictions on new drilling, 16 wells, of which 13 have been productive, have been drilled. All these were completed prior to June. Following that, due to restrictions on drilling on proved locations, no new wells were undertaken until this autumn, when restrictions were eased slightly.

Six new wells are now drilling or are in process of completion in the Wilcox area. In addition three old wells are being redrilled. These involve the sidetracking of original holes and the drilling of new hole to the sand, and for practical effect are the equivalent of new wells. Eighteen workover or reconditioning jobs of various descriptions also were under way on the latest field reports, this reflecting the greatest activity in the field for some time.

Conception of the phenomenon of a lowered fluid level in the pool was developed as a result of studies of reservoir conditions and well behavior made by the Oklahoma City Wilcox Pool Engineering Association, composed of representatives of 30 companies operating in the field. Work of this association, which has complete access to all engineering and operating data of its member companies, has been a major factor in the promotion of efficient and effective drilling and production practices, and making possible important savings to its members.

In the conception of the theory of receding fluid level, or gravity flow of oil, as it sometimes is designated, it is indicated that the Wilcox pool at Oklahoma City does not have an active water drive. Present withdrawals are at least keeping pace with the water encroachment, and for sometime there has been no evidence of water advancement. At places there is evidence of a lowering of the water table, permitting a definite gravity flow of oil down structure.

Original reservoir pressure was approximately 2,600 lb. During the period of comparatively high productivity of wells, the water, due to its viscosity relationship to oil of about 3 to 1 and natural expansion with release of pressure, moved in rather rapidly. As a consequence many wells apparently were drowned out leading to the early belief that such wells and leases were no longer capable of profitable oil production.

For some time there has been no pressure in the reservoir other than the fluid column, which is about 10 lb., and with the decline in oil productivity due to the withdrawals there has been opportunity for the water and oil to assume more normal stabilized relationship, and at the same time recede to somewhat lower fluid levels.

Recession of the oil level leaves a void zone at the top of the sand which fills with gas coming out of solution. This zone is increasing steadily in thickness and extent with continued withdrawals from the reservoir. Consequently, wells producing from the upper part of the sand for various reasons have gradually been forced off production, and in many cases prior to the present redrilling program wells and leases were abandoned. Although the base of the Wilcox in many of these wells is above the present fluid level, some offer opportunity for reclamation either by reworking and deepening or by redrilling.

In many cases it has been impossible to clean out and deepen the wells because of accumulations of junk in the bottoms of the holes. The junk, consisting of pumps, bailers, liners, etc., that have been dropped in the holes from time to time, often extends well up in the sand and have been embedded in sand that has caved in around it. In the days of greater well productivity no particular effort was made to recover this equipment as the wells could easily be produced higher up in the hole. Since then fluid levels have gradually dropped below the top of the junk in many wells so that as the wells have ceased to produce they generally, until comparatively recently, have been abandoned.

Difficulties experienced in drilling of new wells in proved areas are leading operators to attempt the redrilling of the old holes in a number of instances. Such work, coming under the general heading of reconditioning and well maintenance, can be done with limited restrictions, and results generally are successful.

Upwards of 10 old wells have been reclaimed in this way within the past year. The work involves the setting a whipstock at some point sufficiently high in the hole to permit deflecting the hole at not too great an angle and then drilling a new hole to the desired depth in the sand.

Redrilling operation in Oklahoma City field. This well is drilling in its second sidetracked hole

PERMIAN BASIN, PANHANDLE

Large Gas Flow Gaged in Sutton County Wildcat

By W. D. THORN

MIDLAND, Tex.—The old Southern Crude prospect in northern Sutton County claimed new interest last week as S. B. Roberts and M. C. Moore 2 George S. Allison gaged 16,090,000 cu. ft. of sweet gas daily from sand at 3,754-61 ft., total depth. This wildcat previously had made estimated 1,500,000 cu. ft. of gas from 3,650-3,735 ft. which was shut off with 7-in. casing set at 3,740 ft. The increase in gas was found just below a hard 3-ft. cap of sandy lime. The well built up 1,190 lb. pressure on the casing in 20 minutes when shut in, then was opened when gas began showing up on outside of the casing and operators prepared to kill the gas flow with mud. It is located in Section 25, Block K, G.H.&S.A. Survey, and is a diagonal southeast offset to Southern Crude 1 Allison, a 4,942-ft. dry hole abandoned 13 years ago. Nearest production is in the Page field, 10 miles to the northwest, where there are four gas wells and one oil well producing from Strawn pays between 5,370-5,730 ft.

Another Edwards Plateau wildcat, George Livermore and E. M. Wahlenmaier 1 Thomson, in northern Schleicher County, was drilling below 3,800 ft.

Tubb Pay Zone Important

Further successful development of the Tubb pay zone in the Embar area of Andrews County and substantial boost in production resulting from use of acid in Shell 2 Sealy-Smith, Tubb pay producer in Ward County, were among chief developments last week in the West Texas Permian basin.

Phillips Petroleum 22 University-Andrews, Section 20, Block 10, University Survey, extended the Tubb pay zone in the Embar area 1¼ miles north. It made a 2-hour drill-stem test at 6,202-6,325 ft., had a slight gas blow, recovered 6,115 ft. of fluid, of which 855 ft. were clean oil, the balance oily mud and drilling water. It then ran 2-in. tubing with packer set at 6,210 ft., swabbed 2 hours, kicked off and flowed into pits 5 hours, then was turned into tanks and flowed 19 bbl. of oil and 86 bbl. of fresh water in 6 hours, continued testing.

Phillips has requested the Texas Railroad Commission to designate the Tubb pay wells in this area as the Embar-Tubb field. The Ellenburger producers in the area are designated as being in the Embar-Ordovician, while the regular Permian lime wells are classified as being in the Embar or the West Andrews fields.

Atlantic et al 1-A Tex-U, deep wildcat 12 miles northwest of the Embar-Ordovician field, topped Ellenburger lime at 10,575 ft., made a 65-minute drill-stem test at 10,573-10,639 ft., recovered 1,300 ft. of sulfur water with no shows and was drilling ahead at 10,693 ft. in hard dolomite. Low synclinal condition is illustrated by top of Ellenburger being approximately 2,700 ft. lower, subsea, than in the Embar area.

Shell Oil 2 Sealy-Smith, Ward County's first Tubb pay zone producer, and opener of a shallower pay for the 10,000-ft. Monahans field, was treated by stages with 500, 1,000 and 2,000 gal. of acid through the casing perforations at 5,633-43 ft. and on last test flowed 72 bbl. of oil and 4 bbl. of water through tubing in 3 hours. Water was slightly salty, due possibly to bad cement job around oil string which is cemented on bottom at 5,741 ft.

The Texas Co. 1 J. B. Robertson, southern Gaines County wildcat, was scheduled to start pumping potential test this week. It has been shut down for several weeks, installing pumping rig, after swabbing estimated 100 bbl. daily, from lower Permian pay at 5,910-50 ft. Shell Oil 1 Leaverton, wildcat seeking lower Permian production 4 miles southwest of the Wasson field, was drilling at 6,455 ft. in lime.

A scattered group of deep tests, some of which will reach decisive levels soon, include Humble 1 Newman, Scurry County, drilling below 7,780 ft. in shale; Gulf 1 Estes, drilling below surface pipe, and same company's No. 1-A Dawson, shut down, reportedly for repairs, at 2,504 ft., both in Crane County; Magnolia 1 Tucker, northeast offset to their Glenn lease 6,186-ft. Simpson sand producer in Crane County, drilling below 5,200 ft. In Pecos County, Continental 1 Claybrook, Delaware lime test, has cemented surface string at 1,517 ft., Phillips Petroleum 1 Price, 20 miles southeast of Fort Stockton, is drilling below 6,490 ft., and Anderson-Prichard et al 1 Masterson, in Section 24, Block 140, 4 miles southwest of the Masterson field, was drilling at 450 ft. Shell Oil 1 Blue, Winkler County, was drilling below 6,850 ft. and Amon Carter et al 2-C Walton, same county, was past 4,590 ft.

Roy Lee, trustee (H. L. Hunt) 1 J. A. Phillips has awarded drilling contract to Helmerich & Payne for a 4,200-ft. rotary wildcat in southwestern Borden County, in SW NE Section 15, Block 32, Township 3n, T.&P. Survey.

J. S. Merriwether 1 Bobadillo, rank wildcat 2 miles northeast of Vinton in El Paso County, West Texas, logged base of San Andres lime at 958 ft., was drilling at 1,065 ft. in sandy lime and carrying a hole full of water.

WEST TEXAS COMPLETIONS

Wildcats

Howard County: Cosden Pet. Corp. 1 Thelma Cole, SE SE Sec. 14, Blk. 26, H.&T.C. Sur., elev. 2,292 ft., top lime 2,042 ft., dry, T.D. 3,348 ft.

Dickens County: Isaac Deck et al 1 McMahon, NW NW Sec. 319, Blk. 1, H.&G.N. Sur., elev., 2,398 ft., dry, T.D. 1,204 ft.

Fields

West Andrews, Andrews County: Phillips Pet. 9 University-Andrews, NW NW Sec. 32, Blk. 10, University Sur., elev. 3,234 ft., flowed 264 bbl. through tubing, pay 6,210 ft., gas-oil ratio 1,181:1, 44-gravity, acid 3,500 gal., T.D. 8,174 ft., P.B. 6,275 ft., *new pay discovery.*

Phillips Pet. 11 University-Andrews, SE SE Sec. 25, Blk. 11, University Sur., elev. 3,255 ft., flowed 363 bbl. through ¾-in. choke, gas-oil ratio 393:1, gravity 45.1, acid 750 gal., pay 7,865 ft., T.D. 7,799 ft., top Ellenburger 7,818 ft.

Phillips Pet. 18 University-Andrews, NE SW Sec. 12, Blk. 11, University Sur., elev., 3,298 ft., flowed 102 bbl., acid 6,500 gal., pay 4,185 ft., T.D. 4,364 ft.

Slaughter, Cochran County: Anderson-Prichard Corp. 10 Neal, Lge. 57, Refugio C.S.L. Sur., elev. 3,676 ft., flowed 599 bbl., pay 4,902 ft., acid 10,000 gal., T.D. 4,994 ft.

Honolulu Oil Corp. 27-A Mallet, SW SW Lab. 5, Lge. 51, Scurry C.S.L. Sur., elev. 3,649 ft., flowed 590 bbl., pay 5,013 ft., acid 6,000 gal., T.D. 5,060 ft.

World, Crockett County: H. G. Eastham 1 Shannon Est., SW NE Sec. 43, Blk. BB, E.L.&R.R. Sur., elev. 2,611 ft., dry, T.D. 2,628 ft.

Shell Oil 3 Powell, SW SW of lease, Sec. 53, Blk. BB, E.L.R.R. Sur., location abandoned.

Wasson, Gaines County: Amon G. Carter 3-A Langdon, SW NE Sec. 43, Blk. AX, P.S.L. Sur., elev. 3,535 ft., flowed 712 bbl. through ¼-in. choke, pay 4,865 ft., acid 11,000 gal., T.D. 4,990 ft.

Carter-Continental 6-A Willard, NE SW Sec. 39, Blk. AX, P.S.L. Sur., elev. 3,527 ft., flowed 431 bbl. through 19/32-in. choke, pay 4,865 ft., acid 9,000 gal., T.D. 5,010 ft.

Slaughter, Hockley County: J. C. Hawkins 19-A Mallet, SE SE Lab. 22, Lge. 47, Edwards C.S.L. Sur., elev. 3,628 ft., flowed 1,188 bbl., pay 4,935 ft., acid 12,500 gal., T.D. 4,989 ft.

Honolulu Oil Corp. 27-B Mallet, SE SE Lab. 16, Lge. 48, Edwards C.S.L. Sur., elev. 3,616 ft., flowed 444 bbl., pay 4,943 ft., acid 10,000 gal., T.D. 4,985 ft., P.B. 4,970 ft.

Humble Oil 6 Coons, SE SW Sec. 11, Blk. X, P.S.L. Sur., elev. 3,511 ft., flowed 1,246 bbl., pay 4,950 ft., acid 10,000 gal., T.D. 5,020 ft., P.B. 5,002 ft.

Walker, Pecos County: Cardinal Oil 4-B-24 University, NW NE Sec. 24, Blk. 16, University Sur., elev. 3,018 ft., flowed 101 bbl., pay 2,109 ft., shot 80 qt., T.D. 2,131 ft.

Wasson, Yoakum County: Drilling & Exploration Co., Inc. 1 G. W. Davis, SW SW Sec. 729, Blk. D, Gibson Sur., elev. 3,686 ft., flowed 519 bbl., through ⅞-in. choke, pay 5,015 ft., acid 9,000 gal., T.D. 5,225 ft.

Texas-Pacific C. & O. Co. 38 Bennett, NW SW SW Sec. 630, J. H. Gibson Sur., elev. 3.585 ft., flowed 65 bbl. through ⅝-in. choke, gas-oil ratio 446:1, pay 5,200 ft., T.D. 5,261 ft.

(Continued on Page 259)

LOUISIANA GULF COAST

Acadia Parish Wildcat Makes Good Distillate Producer

By T. F. SMILEY

NEW ORLEANS, La.—Neither of two prospective pool openers in southern Vermilion Parish produced anything conclusive in the past week. Union Oil Co. of California 1-C Louisiana Furs, Inc., still at a total depth of 11,985 ft., squeezed perforations at 11,486-93 ft. It set 5½-in. casing at 3,100 ft., cut the casing at 2,740 ft., and at latest reports was washing over at the last-named depth. Humble 1 Louisiana Furs, 8 miles southwest of Schooner Bayou, had nothing of significance to report.

Union Sulphur 2 J. P. Gueno, a wildcat in Acadia Parish, after reaching 10,447 ft. cut the 10¾-in. casing and capped the well with a high-pressure christmas tree. On a 12-hour gage the well made 575 bbl. of distillate, with no water. It had 400 lb. pressure and 140 lb. pressure on the separators. It is now rigging up additional separators.

After cutting and pulling 1,396 ft. of drill stem, leaving the remainder in the hole. Gulf 1 Delta Securities, 1-19-30e, La Fourche Parish, set cement retainer at 1,341 ft. and squeezed the hole. It perforated casing from 1,120 to 1,131 ft., then drilled out to 1,150 ft. It perforated casing from 1,140 to 1,148 ft., set 2½-in. tubing and sealed in casing with packer. The well flowed a small stream of brackish water with a trace of oil. There was no pressure. Preparations to squeeze perforations were begun.

Texas 2 City of New Orleans in Leeville field, La Fourche Parish, was cutting and pulling a stuck drill stem at 4,305 ft. Gulf 1 Delta Securities Co., in the Bayou Couba area of St. Charles Parish, completed as a discovery well last September and the only producer in the field to date, began to make salt water, went dead 2 weeks ago and now is shut in. It had been plugged back to 6,543 ft. from a total depth of 6,917 ft. An electrical survey from 10,900 ft. of Gulf 1-H Amoskeag Savings Bank, in Hayes field, Calcasieu Parish, indicated the Heterostegina zone is 127 ft. lower than in 1 Calcasieu National Bank. It was drilling at 11,330 ft.

LOUISIANA GULF COAST COMPLETIONS

Fields

Pine Prairie, Evangeline Parish: Humble 2 Irma Ortego Guillory, 36-3s-1w, dry at 6,023 ft.

Two Clay County Wildcats May Open New Pools

MATTOON, Ill.—From a standpoint of immediate wildcat possibilities, Clay County ranked first in the Illinois basin at the close of the past week with two operations in or near the stages of testing for production.

East of the Iola area, Homer Luttrell and Paul Doran 1 Reed, NW NE NE 15-5n-5e, showed saturation in the Benoist sand at 2,294-2,307 ft., and operators were preparing to make a drill-stem test. The location of this well is approximately 1½ miles from other oil production. In the Kenner area, L. & W. Drilling Co. 1 Greene Consolidated, SE SW NE 30-3n-6e, had cable tools on location to drill plug and test at a total depth of 2,904 ft. Oil shows were encountered in the Benoist, Aux Vases and Rosiclare formations.

Casing has been set on a wildcat 2 miles south of the Bartelso pool in Clinton County to try for Devonian production at a total depth of 2,477 ft. The well is the J. S. Ashoff, Jr., 1 Huelsmann, NE NE 20-1n-3w, where a saturated core is reported to have been recovered from the Devonian. Operators were preparing to drill plug during the week end.

Also in Clinton County, the Gulf Refining Co. has started a new wildcat 3½ miles due east of the Boulder pool. The test is the 1 E. Martin, SW SE SE 33-3n-1w. Operators completed rigging up and began work on the well late last week. It will test the Benoist and possibly be drilled on to the Devonian.

Saturation Encountered on West Side of Jeff Pool

Although no reports were available at the end of the week, the E. F. Schutte et al 2 C. F. Adkinson, SW NW SE 11-1s-7e, at last reports had not drilled plug to test first McClosky saturation encountered on the west side of the Jeff pool. Saturation was encountered in the McClosky lime at 3,234-39 ft. Production so far in the pool has been from the Aux Vases sand at about 3,100 ft., with new wells making from 100 to 500 bbl. daily on initial tests.

South of the state Game Farm in Jefferson County, Texas Co. 1 D. Baker, SW SE NW 33-3s-3e, was reported to have cored saturated sand in the Aux Vases and is drilling ahead at 3,875 ft. headed for the McClosky. No. 1 Baker is being closely watched by Illinois operators since it is in the same section as a recently completed pool opening Levias and McClosky well.

ILLINOIS COMPLETIONS

Wildcats

Jackson County: G. D. Collins 1-A Boyer, S½ SW NW 21-8s-3w, dry at 730 ft.

McLean County: J. M. McLaughlin 1 Gowan, W½ SW NW 33-34n-5e, dry at 2,261 ft.

Madison County: Versalius & Walker 1 Faires, SW SW NE 35-3n-6w, dry at 2,555 ft., Trenton 2,460 ft.

Oils, Inc., 1 Noll, SW NW SE 28-3n-6w, dry at 2,506 ft., Trenton 2,481 ft.

St. Clair County: L. L. Benoist 1 Holbein, SW SW SW 17-2n-7w, dry at 2,095 ft., Aux Vases 593 ft., Trenton 2,021 ft.

Shelby County: Roy Powers 1 Dunteman, NW SW NE 23-9n-5e, dry at 2,242 ft., Benoist 2,086 ft., McClosky 2,227 ft.

Wayne County: Pure 1 Gaither, N½ SE 36-1n-8e, dry at 3,198 ft., Rosiclare 3,118 ft., McClosky 3,158 ft.

H. Fotiades et al 1 Shewmake, S½ SW SE 23-1n-5e, dry at 3,100 ft., Weller 2,721 ft., Aux Vases 2,916 ft., McClosky 3,031 ft.

Fields

Allendale, Wabash County: Magnolia 5 Payne, NE NW SW 9-1n-12w, pumped 30 bbl., 20-qt. shot, Biehl 1,471-81 ft., T.D. 1,481 ft.

Bluford, Jefferson County: Lario O. & G. 1 Alexander, NW NW NE 1-3s-4e, pumped 432 bbl., acidized, McClosky 3,067-73 ft., T.D. 3,073 ft.

Coll, Wayne County: W. C. McBride 1 Creighton, SE NW SE 19-1s-5e, pumped 30 bbl., Aux Vases 2,897-2,902 ft, 20-qt. shot, T.D. 2,924 ft.

Dale, Hamilton County: Carter 6 Hall, SE NE NE 1-6s-6e, flowed 253 bbl., 40-qt. shot, Aux Vases 3,007-30 ft., T.D. 3,055 ft.

J. O. Freeze 1 Shaw, NW SE NW 13-6s-6e, dry at 3,136 ft., Aux Vases 3,125 ft.

Texas 8-B Hall, SE NW NW 17-6s-7e, pumped 33 bbl., Weller 2,742-66 ft., 5-qt. shot 2,752-57 ft., T.D. 2,768 ft.

Shell 1 Shelton, SE SW NW 18-6s-7e, pumped 40 bbl., 20-qt. shot 3,084 ft., Aux Vases 3,096-3,106 ft., T.D. 3,117 ft.

Texas 6-B Hall, SE SE NE 18-6s-7e, pumped 240 bbl., Weller 2,710-34 ft., 10-qt. shot 2,710-34 ft., T.D. 3,059 ft.

Texas 1 Meeks, NW NE NE 19-6s-7e, pumped 221 bbl., 20-qt. shot, Aux Vases 3,058-78 ft., T.D. 3,082 ft.

Dundas, Jasper County: Pure 3 Dillman, NE NW SW 18-5n-10e, pumped 309 bbl., McClosky 2,811-76 ft., 2,895-2,900 ft., 5,000 gal. acid, T.D. 2,910 ft.

East Centerville, White County: W. C. McBride 6 Gray, NE SE SE 7-4s-10e, pumped 8 bbl., 6-qt. shot 2,455-62 ft., sand 2,460-67 ft., T.D. 2,500 ft.

W. C. McBride 2 Gray, SW NE SE 7-4s-10e, pumped 144 bbl., 20-qt. shot 2,500 ft., sand 2,444-53 ft., T.D. 2,521 ft.

East Inman, Gallatin County: Cherry & Kidd 5 Ker-

(Continued on Page 258)

1st of Tulsa
47 YEARS UNINTERRUPTED SERVICE

EXPERIENCE

The Bank for Oil Men
DIRECTED BY OIL MEN

DIRECTORS

B. F. BARNETT, Vice President
W. M. BOVAIRD, President, Bovaird Supply Co.
J. P. BYRD, Jr., Vice President
F. L. DUNN, Executive Vice President
A. L. FARMER, Real Estate
H. N. GRIES, President, Deep Rock Oil Co.
ELMER HALE, President, Hale-Halsell Co.
A. I. LEVORSEN, Geologist
JOHN D. MAYO, President, Mayo Hotel Co.
R. OTIS McCLINTOCK, President
F. B PARRIOTT, Oil Producer
J. L. SHAKELY, President, Frick-Reid Supply Corp.
W. G. SKELLY, President, Skelly Oil Co.
R. ELMO THOMPSON, President, Superior Oil Co.
GARY Y. VANDEVER, Vandevers'
W. K. WARREN, President, Warren Petroleum Corp.

THE FIRST NATIONAL BANK AND TRUST COMPANY OF TULSA

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

NORTH CENTRAL TEXAS

Seven Wildcats Staked in Revived Drilling Campaign

By W. D. THORN

WICHITA FALLS, Tex. — Independent operators staked a total of seven locations for deep wildcats in Archer, Jack and Young counties last week. Previously started operations indicated opening a new Strawn sand field in the Illinois Bend area, Montague County, a northeastern extension to the deep Forestburg pool in southeastern Montague County, Strawn sand production in the busy Watson pool area of southwestern Clay County. Humble's discovery well in Throckmorton County failed to show as favorably as anticipated on further tests.

R. C. Lipscomb 1 W. F. Harmon, wildcat in the W. C. Winters Survey, 2 miles northwest of Illinois Bend, just south of the Red River, Montague County, encountered mechanical trouble after perforating casing at 3,875-82 ft., then drilled through casing into the sand, ran tubing and was reported swabbing 10 bbl. of oil per hour through tubing, with no water. Hole had been plugged back for the production test from total depth of 4,982 ft. in dry Ellenburger dolomite. It logged several streaks of oil sand in the Strawn section between 3,437 ft. and 3,885 ft.

Sinclair Prairie 1 Hal Steadham, northeast outpost in the Forestburg field, drilled Marble Falls lime showing oil from 7,157-7,201 ft., and was running a drill-stem test prior to setting oil string. On the southwest edge of the field, Magnolia 1 Medley, tested 1 bailer of oil and a show of salt water from the lime between 7,226-75 ft., then treated with 1,500 gal. of acid, after which it had 1,700 ft. of fluid in the hole, mostly oil, to indicate possible completion as a small producer. Continental Oil 1 Ketchum, wildcat 2 miles east of Bowie, drilled out cement to 3,336 ft. and was bailing oil, with no water, still looking like a small producer.

Sinclair Prairie 1 Zachary, in the Sanders field, 4 miles southwest of Nocona, topped Simpson at 6,570 ft., cored oil-stained lime to 6,604 ft., but recovered only 144 ft. of mud on a drill-stem test of the section, and was drilling ahead at 6,670 ft. in dolomite. Youngblood & Foree 1 Quillen estate, wildcat in the Bellows Survey, northwest of the town of Montague, was drilling at 5,649 ft. and reported checking fairly high structurally.

The Watson field in southwestern Clay County had 11 operations under way last week. Production thus far has been from the Caddo lime, between 5,200-5,400 ft., but Whitaker Oil Co. 1 J. L. Gragg, on the southeast edge of the field, looks like a producer from Strawn sand at 3,658-80 ft., as it prepared to shoot with nitro after swabbing at rate of 50 bbl. daily, natural.

Gulf Oil 1 Worsham estate, an old producer in the Ringgold field, on the Clay-Montague County line, deepened from 5,701 ft. and encountered saturated Bend conglomerate at 5,801-05 ft., flowed 472 bbl. of oil in 15 hours through casing, natural, on preliminary test. This well is a south offset to Fain-McGaha 1 Spring which was completed some time ago as a big well from the same pay zone. Majority of wells in the field have found the zone barren.

Youngblood & Foree 1 Sanzenbacher, wildcat 4 miles southwest of Henrietta, Clay County, topped Bend lime at 5,997 ft., was drilling hard lime at 6,045 ft.

In Throckmorton County, Humble Oil 1 Mathews, Mississippian lime discovery well in the A. Tarter Survey, testing pay at 4,592-4,613 ft., after a 2-week shut-in period while building storage, was opened and flowed 110 bbl. of fluid in 3 hours, 50 per cent oil, then swabbed 70 bbl. of fluid, cut 8 per cent water, in 6 hours, and will be completed on the pump. Earlier tests, taken just after acidizing the lime formation, had resulted in flowing rate of approximately 60 bbl. per hour.

Standard Oil of Texas and Hanlon-Buchanan 1 Sally Donnell, new pool opener in western Young County, Section 2371, flowed 401 bbl. oil in 14 hours through ¾-in. choke after using 500 gal. of acid on Mississippian pay at 4,460-4,503 ft. and was waiting on Railroad Commission test.

NORTH CENTRAL TEXAS COMPLETIONS

Wildcats

Archer County: Bridwell Oil Co. 1-I L. F. Wilson, Sec. 32, A.T.N.C.L. Sur., dry, T.D. 1,617 ft.

Fortex Oil Corp. 1 John Conner, N. A. Fitchett Sur. A-887, dry, T.D. 1,206 ft.

White & Duncan et al 1 W. H. Thomas, N. Thomas Sur. A-454, dry, T.D. 1,508 ft.

Wichita County: Helmerich & Payne, Inc. 1 J. L. Jackson, Lot 16, Denton C.S.L. Sur. A-417, dry, T.D. 5,395 ft.

Montague County: Sinclair Prairie 1 J. H. Eanes, G. A. Bench Sur. A1521, 7 mi. SW of Bowie, flowed 70 bbl., pay sandy conglomerate, perf. 5,828-40 ft. and 5,912-22 ft., T.D. 7,070 ft., *discovery*.

Young County: C. V. Welch et al 1 A. A. Donnell, S.P.R.R. Sur. A-1726, dry, T.D. 3,445 ft.

Fields

Watson, Clay County: Roy Lee, trustee, 1 G. J. Conrady, J. H. Fisher Sur. A-154, flowed 185 bbl., Caddo lime pay, perf. 5,484-96 ft., acid 3,000 gal., T.D. 6,031 ft.

Roy Lee, trustee, and Continental Oil 2 Tom Watson, W. A. Farris Sur. A-148, flowed 165 bbl., lime pay 5,455-72 ft., acid 3,000 gal., T.D. 5,494 ft.

Hapgood, Clay County: R. C. Lipscomb 1 L. P. Hapgood, Sec. 60, Marion C.S.L. Sur., dry, T.D. 6,065 ft.

Walnut Bend, Cook County: Sinclair Prairie 12 N. Atkins, Lot 69, Fannin C.S.L. Sur., pumped 227 bbl., pay 4,829 ft., T.D. 2,854 ft.

Davenport, Cooke County: Seitz, Comegys & Seitz 1 V. Pitman, Jas. Ferguson Sur. A-261, dry, T.D. 3,167 ft.

Hoefle, Jack County: Taubert-McKee and Sinclair Prairie 2 Mary Hoefle, A. James Sur. A-318, pumped 112 bbl. oil and 30 bbl. water per day, pay 4,819

(Continued on Page 259)

REGISTERED PROFESSIONAL ENGINEERS

Air • Gas • Water

REPRESSURING

RECYCLING • PRESSURE MAINTENANCE

INSTALLATION • OPERATION

PETROLEUM ENGINEER
JO H CABLE
WICHITA FALLS TEXAS

GAS MEASUREMENT • PERMEABILITY
COMPRESSOR PLANTS • POROSITY
BOTTOM HOLE PRESSURE • SATURATION
GAS OIL RATIOS • RECOVERABLE OIL
CONTROL OF FLOW THRU FORMATION

REGISTERED PROFESSIONAL ENGINEERS

EQUAL DISTRIBUTION OF PRESSURE

UNIBOLT Couplings with their three interlocking shelves, or 3-point suspension, employ a proven principle and thus assure equal distribution of pressure on the seal ring.

THORNHILL-CRAVER COMPANY
HOUSTON

UNIBOLT
THE ONE BOLT COUPLING

G. A. WELDING Shop Notes

UP SHE GOES!

Making steel plate equipment is only part of the service offered by General American's Plate and Welding Division. Veteran crews of erection men are maintained in various parts of the country to make certain that the finished job is set up properly. This final step completes the cycle of precision manufacturing — from engineering through to fabricating, stress-relieving and testing — to assure you of 100% value on every G. A. "Fluid-Fusion" Welded Product.

PLATE AND WELDING DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION

Cable Address
GENTANWELD
Sharon, Pa.

GATX GENERAL AMERICAN
PLATE & WELDING DIVISION
PLANT AT SHARON, PA.

Offices In All Principal Cities

Two Gas Fields Extended In Southeast Ohio

ZANESVILLE, Ohio.—In Ohio two gas pools were extended and a third had a showing of both oil and gas. Wiser Oil Co. 1 C. D. Eastwood extended the Hinckley pool of Medina County ½ mile northwest when it flowed 5,000,000 cu. ft. of gas from Clinton sand at 3,491 ft. Rock pressure was 1,220 lb. The other extension was in Guernsey County where Ohio Fuel Gas 1 Luella Kennedy, Section 21, gaged 2,590,000 cu. ft. of gas in Oriskany sand at 3,198-3,213 ft. Successful completion of the well carried the Oriskany pool ½ mile east. A number of other gas wells were reported in Stark and Wayne counties.

In Meigs County, Section 22, Olive Township, Sinclair Prairie 1 George Longsworth found a show of gas in the top and oil in the bottom of a sand at 4,057-72 ft. The well is to be drilled to the Clinton sand but on last report was shut down at 4,075 ft. to test the oil showing. Top of Niagara lime was at 3,977 ft.

SOUTHEAST OHIO COMPLETIONS

Ashland County, Mohican Township: Ohio Fuel 1 C. C. Hare, Sec. 5, 848,000 cu. ft. gas, Clinton, T.D. 2,927 ft.

Lake Township: Kemrow Co. 5 C. S. Reese, Sec. 22, dry, Clinton, T.D. 2,871 ft.

Athens County, Rome Township: Milhoon 14 O. O. Bryson, Sec. 14, dry, Cow Run, T.D. 393 ft.

McBill Oil Co. 9 H. M. Antle, Sec. 30, 10 bbl., T.D. 453 ft.

Trimble Township: Ohio Fuel Gas Co. 7246 Sunday Creek Coal Co., SW Sec. 33, dry, through Berea, T.D. 972 ft.

Trimble Township: Ohio Fuel 216 Sunday Creek Coal Co., Sec. 33, dry, Berea, T.D. 972 ft.

Canaan Township: Wallace et al 1 Nettie Halbirt, Fraction 6, 50,000 cu. ft. gas, Berea, T.D. 1,325 ft.

Rome Township: Gross & McCune 8 Grant Antle, Sec. 30, 10 bbl., Cow Run sand, T.D. 474 ft.

N. C. Leeper 28 O. O. Bryson, Sec. 29, dry, T.D. 389 ft.

Guernsey County, Wheeling Township: Ohio Fuel 1 Luella Kennedy, Sec. 21, 2,590,000 cu. ft., Oriskany sand 3,198-3,213 ft., T.D. 3,215 ft.

Hocking County, Starr Township: M. H. Porter 1 Hocking & Athens Coal Co., SE Sec. 5, 400,000 cu. ft. gas, Berea, T.D. 997 ft.

Knox County, Brown Township: Ohio Fuel 1 Amelia Pinkley, Sec. 11, dry, Clinton, T.D. 2,891 ft.

Howard Township: H. E. Perkins 2 Jesse White, Lot 21, dry, Clinton, T.D. 2,758 ft.

Licking County, Perry Township: C. R. Settles 7 Ethel Frost, SW Sec. 14, 3 bbl., Berea, T.D. 628 ft.

Lorain County, Columbia Township: Ohio Fuel 1 M. Churchward, Lot 75, dry, Clinton, T.D. 2,738 ft.

Huntington Township: Ohio Fuel 1 A. E. Archer, Lot 12, dry, Clinton, T.D. 2,659 ft.

Medina County, Granger Township: M. L. Packard et al 17 Anna L. Crocker, Lot 25, 75 bbl., Berea, T.D. 462 ft.

Hinckley Township: H. C. Bishop 1 C. C. Lorenz, Lot 55, dry, through Clinton sand, T.D. 3,308 ft.

H. C. Bishop 1 Lillie Bellus 1 lease Lot 55, dry, through Clinton, T.D. 3,302 ft.

Ohio Fuel 1 Anna Dieckman, Lot 41, dry, Clinton, T.D. 3,477 ft.

Wiser Oil 1 C. D. Eastwood, Lot 29, 5,000,000 cu. ft., Clinton, T.D. 3,491 ft.

Muskingum County, Blue Rock Township: Atha 2 Paul Persin, Sec. 9, 942,000 cu. ft., Clinton, T.D. 4,391 ft.

Washington Township: Wittmer 1 Naaman Vernon, Lot 10, 819,000 cu. ft., Clinton 3,997-4,042 ft., T.D. 4,042 ft.

Meigs County, Orange Township: H. B. Walker & Co. 3 Graner C. Griffin, at Alfred Sec. 36, 2,380,000 cut. ft. gas, first Berea, T.D. 1,638 ft.

Columbia Township: Utsinger 1 Harry Lewis, Sec. 32, dry, Berea, T.D. 1,224 ft.

Monroe County, Franklin Township: Raymond Newhart et al 1 Bode Bros., NE Sec. 6, dry, through lime, T.D. 1,300 ft.

Wayne Township: Gold Crown Oil & Gas 1 John Christy, NE Sec. 19, dry, lime, T.D. 1,310 ft.

Franklin Township: Detler Bros. 1 John Curtis heirs, Sec. 7, 134,000 cu. ft. and 1 bbl. oil, salt sand, T.D. 1,580 ft.

Morgan County, York Township: Pure Oil 1 M. J. Stoneburner, Sec. 30, 100,000 cu. ft., Berea, T.D. 1,228 ft.

Ohio Fuel 1 C. L. Weaver, Sec. 26, 157,000 cu. ft., Berea, T.D. 1,169 ft.

Noble County, Marion Township: Whigville Gas 1 F. E. Danford, Sec. 1, dry, Berea, T.D. 1,844 ft.

Perry County, Clayton Township: Preston Oil 2 J. F. Pennington, Sec. 9, 10 bbl. oil, Clinton, T.D. 3,367 ft.

Bearfield Township: Ohio Fuel Gas Co. 2 R. C. Coulter, NE Sec. 34, dry, through Clinton sand, T.D. 4,238 ft.

Clayton Township: Industrial Gas Corp. 1 Mary J. King, NE Sec. 2, 25,000 cu. ft. gas, will be plugged, T.D. 3,360 ft.

Industrial Gas Corp. 1 John Hough, SW Sec. 1, 2,000,000 cu. ft. gas, Clinton sand, T.D. 3,365 ft.

Stark County, Pike Township: Lyons 5 O. C. Barber, Sec. 10, 3,400,000 cu. ft. after shot, Clinton 4,887-4,913 ft., T.D. 4,914 ft.

Tuscarawas County, Sandy Township: Columbia Carbon 1 Lillie Norris, Sec. 32, 184,000 cu. ft., Clinton, T.D. 5,028 ft.

Washington County, Liberty Township: Burkhart 5 W. J. Hail, 80,000 cu. ft., Keener, T.D. 1,500 ft.

Wayne County, Plain Township: Ohio Fuel 1 Wayne Alleman, Sec. 22, 1,250,000 cu. ft. and 7 bbl. oil, Clinton, T.D. 3,284 ft.

Clark 1 J. A. Stauffer, Sec. 21, 880,000 cu. ft., Clinton, T.D. 3,170 ft.

INDIANA

EVANSVILLE, Ind.—In the Eureka pool, about 7 miles west of Rockport, two operations are in progress. They are the W. W. Damron and Gary 1 E. L. Hall, NW NW SW 34-7s-7w, drilling near 1,500 ft., and the E. E. Schaaf 1 Wilderson, NE NW NW 2-8s-7e, drilling at about 1,050 ft.

Damron & Gary have shut down operations on the 1 W. H. Jones, NW NE SW 34-7s-7w, at a total depth of 725 ft. and R. Laughton 1 H. E. Parker, NW SE NW 32-77s-7w, has been completed as a dry hole at a total depth of 1,787 ft.

In Wayne County, the Wayne County Producing Co. is fishing for tools at the 1 F. Taylor, NW SW NE 22-13n-1w, 8 miles northwest of Martinsville.

In the new Vernon Heights pool, Vanderburg County, Sells Petroleum is moving in material to drill the 4 J. A. McCarty, SE SW NW 32-6s-11w, after having set casing to test the Waltersburg sand at 1,795-1,801 ft. In the 1 Schutte-Webber unit. George Nelson and the United Oil Co. are reported drilling on the 1 A. Walling unit, SW NW NE 32-6s-11w.

INDIANA COMPLETIONS

Adams County: J. O. Ruff 1 Ruff, SE SE SW 16-25n-13e, dry, T.D. 1,063 ft., Trenton 1,028 ft.

Gibson County: Carroll Oil 2 Corecelius, NW NW SE 36-1s-10w, flowed 35 bbl., pay 1,322-27 ft., T.D. 1,338 ft.

F. B. Hillis 1 Hayes, NW NE SW 26-1n-10w, dry, T.D. 1,811 ft.

Posey County: Carter and Gulf 2 Gempler, NE SE SE 36-6s-14w, dry, T.D. 1,301 ft.

C. E. Breham 1 Hageman, SE SW SE 12-8s-14w, dry, T.D. 2,590 ft., Cypress 2,530 ft.

C. E. Breham 1-A Hardwick, SE SE SE 12-8s-14w, pumped 24 bbl., pay 1,096-1,105 ft., T.D., *discovery of Hovey Lake pool.*

Spencer County: Mecca Oil 1 Parker, SE NE NW 32-7s-7w, dry, T.D. 1,787 ft., Ste. Genevieve 1,608 ft.

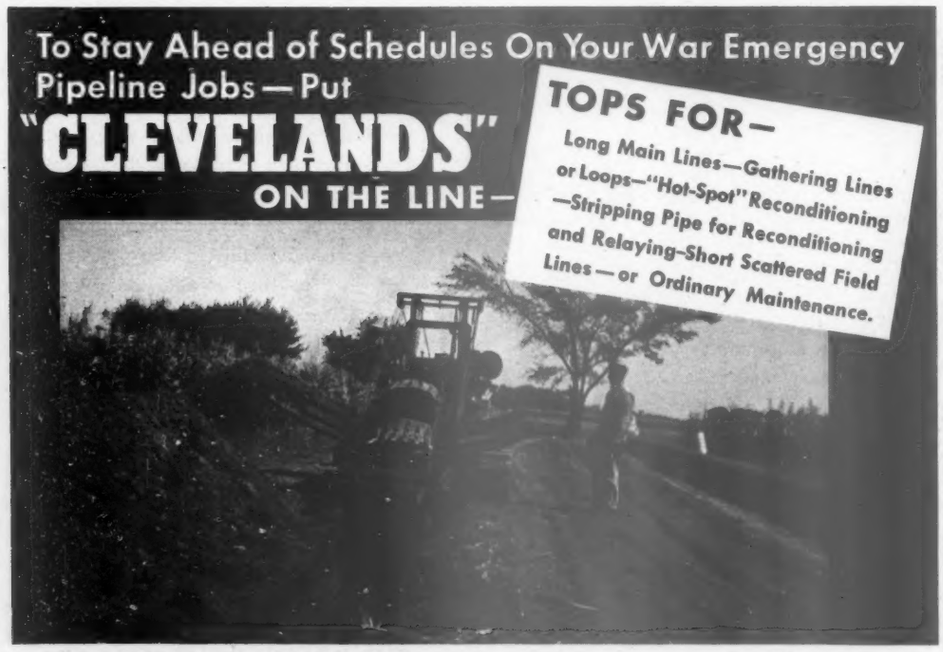
Vanderburg County: Sells Pet. 4-A McCarthey, SE NE NW 32-6s-11w, pumped 70 bbl., natural, Waltersburg 1,799-1,803 ft., T.D. 1,809 ft.

EASTERN KENTUCKY

ASHLAND, Ky. — Operations in eastern Kentucky last week were highlighted by the completion of 1 oil well, 1 gas and 1 dry well, while the general activities showed a slight improvement.

Two new locations were filed and a report from Lee County reveals that drilling in No. 14, M. F.

(Continued on Page 258)


To Stay Ahead of Schedules On Your War Emergency Pipeline Jobs—Put
"CLEVELANDS"
ON THE LINE—
TOPS FOR—
Long Main Lines—Gathering Lines or Loops—"Hot-Spot" Reconditioning —Stripping Pipe for Reconditioning and Relaying-Short Scattered Field Lines—or Ordinary Maintenance.

In "CLEVELANDS" power, speed and traction to take them anywhere, in any type of soil, are coupled with the ultimate in strong, long wearing material. Thus not only mere repair costs but even more serious service interruptions, which slow down work, are brought to a minimum and you are able to beat ditching schedules.

BUY WAR BONDS—THROW THE SCRAP (METAL and RUBBER) INTO THE FIGHT

THE CLEVELAND TRENCHER COMPANY
20100 ST CLAIR AVE "Pioneer of the Small Trencher" CLEVELAND, OHIO
"CLEVELANDS" Save More . . . Because they Do More

EASTERN TEXAS FIELDS

Grapeland Discovery Well Is Gasser With Some Distillate

By W. D. THORN

DALLAS, Tex.—Final gage on a new Woodbine sand gas discovery in northern Houston County was reported last week, with no unusually important developments being recorded elsewhere in the East Texas district.

American Liberty Oil Co. and Russell Grimes et al 1 M. B. Ellis, in the J. Daly Survey, 5 miles northeast of Grapeland in northern Houston County, on Railroad Commission gage rated open flow capacity of 29,000,000 cu. ft. of gas, with 15 bbl. of distillate, daily, from casing perforations opposite Woodbine sand at 5,932-39 ft.

Shell Oil 1 E. H. Massey, a new Woodbine sand wildcat on a 117.8-acre tract in the F. Bettick Survey, and on the Tennessee Colony prospect in Anderson County, has spudded. B. F. Phillips 1 Kay, Paluxy sand wildcat near Friendship in Smith County, in the Oscar Hawkins Survey, was preparing to spud. E. B. Germany et al of Dallas are reported completing arrangements to start a Paluxy sand wildcat in southeastern Hopkins County, in the H. P. Barron Survey, 3 miles southeast of Pickton.

Humble Oil & Refining Co. has moved rig back in to rework its 1 Curtiss, northern Cherokee County wildcat which was completed several weeks ago as a Pettit lime producer at the 10,200-ft. level with initial production of only 37 bbl. daily.

Nacogdoches County's deepest test, Texas Co. 1 Strahan, 7 miles northeast of Nacogdoches, was drilling at 8,735 ft. in sand, probably Travis Peak, with no shows reported. It topped Pettit at 8,020 ft.

P. D. Bowlen et al 1 Sims estate, Bowie County wildcat seeking Smackover lime production, was drilling below 7,460 ft. in sand and shale with top of the lime expected around 8,000 ft.

Delta Drilling Co. et al 1 Gentry, wildcat 3 miles southwest of Athens, Henderson County, was drilling below 7,440 ft. in lime, checking approximately 225 ft. low structurally with the lone gas-oil producer in the Tri-City field about 3 miles to the southwest. A Franklin County wildcat, R. T. Myers et al 1 Cox, 5 miles north of Winnsboro, topped Paluxy at 5,985 ft. by log, then cored from 5,998-6,006 ft. with recovery of white sand carrying no shows of oil or gas. In Wood County, Delta Drilling Co., Rube Benton et al 1 Goldsmith, Quitman area deep test, was drilling at 5,010 ft. in Georgetown lime topped near that depth, and Magnolia 1 McCreight, Yantis area, had spudded below 350 ft.

Two new Paluxy sand oilers were added in the northern part of the Coke field last week, Amerada completing 1 J. D. Kennemer with gage of 91.44 bbl. in 6 hours through ¼-in. choke, and J. C. Hawkins 2 Clark gaging 95.96 bbl. in 6 hours through ¼-in. choke. Amerada had five active operations in the field at close of the week.

J. C. Hawkins, Tyler operator, has asked permits to drill eight wells on the Pinkston heirs lease in the J. B. Cadena Survey, East Texas field, Rusk County, being first indication of drilling activity in the field for several months.

A new Smackover lime test on the Balcones fault trend is being started by J. B. Stoddard of Dallas at 1 W. E. Smith, in the J. B. Edwards Survey, in southeastern Ellis County. The location is on a 4,000-acre block farmed out by Texas Co. Drilling contract for the 6,500-ft. test was let to Prince Brothers.

Two Shelby County wildcats have been abandoned as dry. Imperial Petroleum Co. 1 Hansen, northeast of Shelbyville, tested noncommercially in several zones above total depth of 5,361 ft., and E. E. Hurley et al 1 Frost Lumber Co., W. N. Waterman Sur., was abandoned at a total depth of 6,786 ft. In the same county, Humble Oil 1 Adams, Arcadia area wildcat, was drilling below 5,890 ft.

EAST TEXAS COMPLETIONS

Wildcats

Freestone County: C. C. Lanier 1 L. A. Gilliam, J. B. McElyea Sur., 2½ mi. W of Freestone, location abandoned.

Houston County: American Liberty Oil Co. and Russell Grimes 1 M. B. Ellis, SE¼ of 101-acre lease in J. Daly Sur., 5 mi. NE of Grapeland, elev. 445 ft., potential 29,000,000 cu. ft. gas with 15 bbl. distillate, pressure 1,785 lb., perf. 5,932-39 ft., top Woodbine 5,922 ft., T.D. 5,955 ft., *gas discovery.*

Fields

Chapel Hill, Smith County: Sinclair Prairie 2 Will Walton, T. Wolfe Sur., north edge field, elev. 465 ft., flowed 352 bbl. through ¼-in. choke, perf. 8,047-799 ft., acid 5,000 gal., T.D. 8,268 ft.

Talco, Titus County: Lucey Pet. Corp. 18 I. N. Williams, location abandoned.

Coke, Wood County: Amerada 1 J. D. Kennemer, B. Smith Sur., flowed 991.44 bbl. in 6 hr. through ¼-in. choke, perf. 6,388-98 ft.; T.D. 6,416 ft., P.B. 6,398 ft.

J. C. Hawkins 2 J. M. Clark, B. Smith Sur., elev. 500 ft., flowed 96 bbl. in 6 hr. through ¼-in. choke, perf. 6,297-6,345 ft., T.D. 6,349 ft.

Hawkins, Wood County: Humble Oil D-10 B. F. Allen, 911 ft. E of No. D-9, George Brewer Sur., dry, T.D. 4,825 ft.

Humble Oil D-1 Tom Jackson, George Brewer Sur., flowed 94 bbl. in 6 hr. through ¼-in. choke, perf. 4,665-73 ft. and 4,805-19 ft., T.D. 4,870 ft.

Humble Oil 3 W. R. Parrish, H. F. Watson Sur., top Woodbine 4,436 ft., dry, T.D. 4,559 ft.

Humble Oil 2 J. C. Snow, J. B. Crane Sur., dry, T.D. 4,955 ft.

Humble Oil 4 J. C. Snow, W. Herrington Sur., *correction:* flowed 89.22 bbl. in 6 hr. through ¼-in. choke, perf. 4,865-78 ft. and 4,795-4,803 ft., T.D. 4,901 ft.

Humble Oil 4 B. A. Wells Est., George Brewer Sur., dry, T.D. 4,576 ft.

(Continued on Page 259)

SOUTHWEST TEXAS

Berclair, Bee County Deep Wildcat to Be Abandoned

CORPUS CHRISTI, Tex.—After making 7 bbl. in a 12-hour test early in October at 10,080 to 10,120 ft. Magnolia's wildcat 2 miles southwest of Berclair, in the T. Simons Survey, Bee County, has shut down and is reported waiting on a permit to abandon.

Ginther, Warren & Ginther 1 Carrie Wood, in the Sarco Creek area of Goliad County, 9 miles southeast of Goliad, tested 180,000,000 cu. ft. of gas on open flow in 24 hours. The shut-in pressure was 1,730 lb. This well, with total depth of 5,250 ft., perforated casing at 4,170-80 ft.

Richardson Petroleum Co. 2 J. O. Chapman, a Nueces County wildcat, tested 820,000 cu. ft. of gas and an estimated 25 bbl. of distillate through ⅛-in. choke, with perforations at 5,967-74 ft. Tubing pressure was 2,052 lb. and casing pressure 2,225 lb.

Continental 5 St. Charles Co., in St. Charles field, Aransas County, set packer at 8,153 ft. and swabbed. The well flowed salt water, with a small quantity of gas and distillate.

In a further test Ogden & Voyles 1 Richardson, 3 miles south of the Kohler field in Duval County, pumped 31 bbl. of oil and 42 bbl. of salt water in 26 hours. Testing was being continued at 2,957 ft. Sun 1 Cortez, a wildcat 5 miles southeast of the Boyle field in Starr County, was reported temporarily abandoned at 4,620 ft.

Sun 3 Brooks, a wildcat 5 miles northwest of Agua Nueva in the Santo Domingo de Abajo grant, in Jim Hogg County, was completed dry at 5,503 ft.

SOUTH TEXAS COMPLETIONS

Wildcats

Jim Hogg County: Sun 3 L. R. Brooks, Santo Domingo de Abaja grant, dry at 5,503 ft.

Fields

Colorado, Jim Hogg County: Humble 3 T. T. East, 61 bbl. in 10 hr. through ⅛-in. choke, T.P. 50 lb., C.P. 400 lb., gas-oil ratio 200:1, T.D. 3,183 ft.

Casa Blanca, Duval County: M. L. Massingill 17 D.C.R.C. Sur. 294, pumped 30 bbl. at 1,069 ft.

M. L. Massingill 18, D.C.R.C. Sur. 194, pumped 28 bbl. at 1,060 ft.

Garcia, Starr County: Sun 3-A Garcia Land & Livestock Co., dry at 3,906 ft.

North Sun, Starr County: Sun 2 Olivares, 415 bbl. in 8 hr. on 9/64-in. choke, T.P. 720 lb., C.P. 1,070 lb., gas-oil ratio 931:1, T.D. 4,555 ft.

Rincon, Starr County: Cintinental and Davis 76-A Slick estate, 41 bbl. through ⅛-in. choke, perf. 4,134-40 ft., T.P. 280 lb., C.P. 540 lb., gas-oil ratio 2,336:1, T.D. 4,141 ft.

Continental and Davis 7-D Slick estate, 202 bbl. through ⅛-in. choke, T.P. 440 lb., C.P. 970 lb., gas-oil ratio 355, T.D. 3,972 ft.

LOWER GULF COAST COMPLETIONS

Wildcats

Hidalgo County: Baldridge & King 1 Oscar Descam, dry at 6,012 ft.

Baldridge & King 2 Oscar Descam, dry at 4,515 ft.

Baldridge & King 1 Yturria Town & Improvement Co., dry at 4,755 ft.

Karnes County: H. J. Baker et al 1 Joe T. Warzecha, dry at 2,006 ft.

Fields

Clara Driscoll, Nueces County: E. J. Brooks Co. 1 A. Scubert, dry at 5,296 ft.

Ben Bolt, Jim Wells County: Bridwell Oil Co. 1-D N. A. Hoffman, 1,750,000 cu. ft. gas through ⅛-in. choke, perf. 5,247-59 ft., T.P. 745 lb., C.P. 805 lb., S.I. pressure 2,025 lb., T.D 5,508 ft.

Bridwell Oil Co. 1-I N. A. Hoffman, 6,400,000 cu. ft. gas through ½-in. choke, T.P. 785 lb., C.P. 2,055 lb., T.D. 5,859 ft.

Seeligson, Jim Wells County: Magnolia 35 Seeligson, 119 bbl. 20 hr. through 7/64-in. choke, perf. 5,912-15 ft., T.P. 1,040 lb., C.P. 1,330 lb., gas-oil ratio 770, T.D. 5,950 ft.

Shell 9 L. Seeligson, 67 bbl. through 7/64-in. choke, perf. 5,947-56 ft., T.P. 350 lb., C.P. 1,300 lb., gas-oil ratio 705, T.D. 6,065 ft.

South Caesar, Bee County: Luling Oil & Gas Co. 4-WB Tom Slick, dry at 6,651 ft.

Stratton, Kleberg County: Humble 21 King Ranch-Ancho, 109 bbl. through ¼-in. choke, T.P. 900 lb., C.P. 1,100 lb., gas-oil ratio 784, T.D. 6,643 ft.

Chicago Corp. 45 G. P. Wardner, 114 bbl. through ¼-in. choke, perf. 6,396-6,400 ft., T.P. 800 lb., C.P. 960 lb., gas-oil ratio 960, T.D. 6,590 ft.

SOUTH CENTRAL TEXAS COMPLETIONS

Fields

Bee Creek, Caldwell County: Ralph R. Ogden 19 F. H. Tally, 72 bbl. on pump.

KANSAS, NEBRASKA

Gas Discovered in Edwards County Near McCarty Field

By CARL HOOT

THERE were 30 completions last week in Kansas, with no significant development reported from wildcat operations. Of the seven wildcats finished during the week, six were dry and one was a gas discovery. In eastern Edwards County, Cities Service 1 English, NE NE NE 8-25-16w, flowed 25,000,000 cu. ft. of gas in Lansing lime at 3,807-15 ft., total depth was 4,650 ft. The well is about 8 miles northeast of the old McClosky pool, where small production was found and a few gas wells drilled. Gas was discovered in the McCarty area in 1929, coming from the Sooy zone at 4,545 ft.

Stafford County received a new oil pool and extended another. Five miles west of the Drach pool, Vickers Petroleum Co. 1 Curtis, CSL SW NW 6-22-13w, was given a top potential of 3,000 bbl. of oil daily from Arbuckle dolomite topped at 3,693 ft. Seven-inch casing was set at this depth and the hole drilled on down to 3,700 ft. Other tops logged were the Lansing lime at 3,366 ft., which had several shows of oil; Viola at 3,629 ft. and Simpson sand at 3,646 ft. The well is just south of the town of Seward. On the east side of the Drach pool, Atlantic Refining Co. 1 Hitz, SW SW 7-22-12w, was reported swabbing 50 bbl. of oil an hour from Arbuckle at 3,679-83 ft.

In northwestern Russell County, 2½ miles east of the Fairport pool, Auto Ordnance Corp. 1 Sutton, SW NW NW 2-12-15w, was showing for a prospective pool opener after finding good porosity and some saturation in Arbuckle dolomite at 3,270 ft. Lansing lime was topped at 2,944 ft. and fair porosity with good saturation reported at 3,008-10 ft. Although the Fairport pool is an old one, discovered in November 1923, the Sutton well is in an untested area and if productive will open considerable acreage for drilling. Production at Fairport is from Lansing-Kansas City lime at 2,950 ft. and Gorham sand at the 3,000-ft. level.

KANSAS COMPLETIONS

Wildcats

Edwards County: Cities Service 1 English, NE cor. 8-25-16w, 25,000,000 cu. ft. gas, Lansing lime 3,807-15 ft., T.D. 4,650 ft., top Lansing 3,784 ft., perf. 3,953-54 ft. and showed some oil.

Leavenworth County: Heuisman 1 Bracy, NW SW 13-11-21e, dry, T.D. 1,116 ft., Mississippi lime 1,115 ft.

Norton County: Cities Service 1 Business Men's Assn., NE NE NW 6-5-22w, dry, T.D. 3,775 ft., Lansing 3,404 ft., granite wash 3,733 ft., granite 3,772 ft.

Pratt County: Hollow Drlg. 1 Brown, SW SE NE 5-27-12w, dry, T.D. 4,426 ft., Lansing 3,690 ft., Mississippi lime 4,131 ft., Viola 4,258 ft., Simpson 4,310 ft., sand 4,333 ft., Arbuckle 4,396 ft.

Rooks County: Helmerich & Payne 1 Coulter, NW NW SW 14-9-20w, dry, T.D. 3,775 ft., Lansing 3,350 ft., Arbuckle 3,676 ft., show heavy black oil 3,676-99 ft.

Sedgwick County: H. M. Williams 1 Gsell, NE NE SE 33-26-3e, dry, T.D. 3,253 ft., Lansing 2,105 ft., Mississippi lime 2,912 ft., Viola 3,252 ft., show oil 3,223-26 ft.

Stafford County: Helmerich & Payne 1 Va n Sickle, SW SE SE 26-25-12w, dry, T.D. 4,270 ft., Lansing 3,608 ft., Viola 4,085 ft., Simpson 4,170 ft., Arbuckle 4,238 ft., show oil 4,238-42 ft.

Fields

Doran, Rice County: C. H. Weaver 1-A Katterjohn, E½ NE SW 13-19-10w, pumped 36 bbl. in 4 hr., Arbuckle 3,275-92 ft.

Eudora, Douglas County: J. M. Edwards 2 Durr, NE SE 18-13-21e, dry, T.D. 905 ft., sand 753 ft.

Hazel, Stafford County: W. P. Faulkner 1 Keenan, W½ SW SW 28-21-13w, dry, T.D. 3,841 ft., Viola 3,767 ft., Simpson 3,799 ft., Arbuckle 3,832 ft.

Iuka, Pratt County: Magnolia 2 Beck, SW SW NW 12-27-13w, pumped 400 bbl., Simpson sand 4,314 ft., T.D. 4,332 ft.

Kraft-Prusa, Barton County: Ohio Oil 2 Riemann, NW SW 4-17-11w, pumped 472 bbl., Arbuckle 3,319-25 ft.

Magnolia 4 Riemann, NW SE 4-17-11w, 3,000 bbl., Arbuckle 3,284-91 ft.

Black-Marshall Oil 2 Ney, approx. NW NE 17-16-11w, dry, T.D. 3,335 ft., Arbuckle 3,323 ft.

Laton, Rooks County: Max Cohen 4 Doane, S½ NE SW 34-8-16w, pumped 484 bbl., Lansing 3,097-3,146 ft.

Lost Springs, Marion County: Adair & Morton 1-A Schick, SE SW 29-17-4e, dry, T.D. 2,478 ft.

Medicine Lodge, Barber County: Barbara Oil 1 Lasswell, C SW 20-33-13w, 22,750,000 cu. ft. gas, Mississippi lime 4,659-87 ft., T.D. 4,705 ft.

McLouth, Jefferson County: O. J. Connell 3 Edmonds, SE NE 21-9-20e, dry, T.D. 1,545 ft., sand 1,420 ft., Mississippi lime 1,541 ft.

Peace Creek, Reno County: Cities Service 1-C Heylmun, SW SW NE 12-23-10w, 3,000 bbl., Viola 3,735-42 ft.

Quincy, Greenwood County: Bisagno 10 Gilroy, N½ NW NE 6-25-13e, pumped 24 bbl., Mississippi lime 1,639-68 ft.

Ray, Phillips County: Cities Service 1 Kohlman, SW NW NE 33-5-20w, pumped 400 bbl., Lamotte sand 3,552-70 ft.

Cities Service 3 States, SW NE SE 30-5-20w, pumped 72 bbl., Arbuckle and Lamotte 3,644-52 ft., top Arbuckle 3,637 ft., Lamotte 3,646 ft.

Raymond, Rice County: Hyde & Stormfeltz 1 Warner, S½ NE NW 15-20-10w, pumped 425 bbl., Lansing 3,151-55 ft., T.D. 3,180 ft.

Smyres, McPherson County: Continental 1-A Conrad, NE SW NW 31-19-5w, dry, T.D. 3,485 ft.

Nelson Drlg. 2 Anderson, NE SW SW 25-19-6w, pumped 239 bbl., Mississippi lime 3,303-43 ft.

Trapp, Barton County: Vernon Oil 1 Peace, SE NE NW 30-16-13w, pumped 347 bbl., Arbuckle 3,396-3,410 ft.

Continental 2 Stoskopf, SE NW NW 20-16-13w, dry, T.D. 3,420 ft.

Trapp, Russell County: V. D. Sidey 2 Hill, E½ SW NE 20-15-13w, pumped 787 bbl., Lansing 3,087-3,107 ft., T.D. 3,119 ft.

Vernon North, Sumner County: Arthur Brewer 1 McCorgary, SW NW NW 14-35-2e, dry, T.D. 3,517 ft.

Youngmeyer, Elk County: Allison & Phillips 2 Youngmeyer, NW NW NE 25-28-8e, water-disposal well, T.D. 2,863 ft.

TEXAS GULF COAST

Nome Wildcat Abandoned in Frio Sand; Fig Ridge Extended

By T. F. SMILEY

HOUSTON, Tex.—Hebert & Smith 1 G. W. Conger, a wildcat test in the Nome area of Liberty County, was junked and abandoned after drilling to 7,243 ft. The crew lost five joints of drill pipe at that depth and all efforts to fish them out failed. This well found the Miocene Discorbis at 3,188 ft., Discorbis 5,393 ft., restricted Discorbis 5,573 ft., Heterostegina 5,820 ft., Round Marginulina 5,932 ft., Flat Marginulina 6,084 ft., Frio 6,150 ft.

With the completion of Sun 1-C Doornbos the Fig Ridge area of Chambers County is extended to the northwest. The well was producing 139 bbl. of oil through ⅛-in. choke at a total depth of 8,340 ft.

Ohio 1 Roy Kaeschele, an Austin County wildcat 3 miles southeast of Orange Hill in the V. Flores Survey, was still undergoing test. The 2-in. tubing was swung at 9,180 ft. and the well flowed 45 bbl. of fluid in 24 hours through ⅛-in. choke with tubing pressure of 2,500 lb. and casing pressure of 2,950 lb. The fluid showed 94 per cent distillate and 6 per cent b.s and water.

Humble 1-B Houston Farm Development Co., a wildcat test in the Halls Bayou area of Brazoria County, was drilling ahead at 10,307 ft. Humble 1 San Antonio Joint Stock Land Bank, a wildcat in the C. Lasso Survey of Jackson County, was shut down at 692 ft. Renwar 1 W. D. Freeman, 2 miles southwest of Ganado in Jackson County, was waiting on casing at 6,651 ft. Fidelity Oil & Royalty Co. 1 W. L. Sartwell, in the J. Frazier Survey, Lavaca County, had a fishing job at 6,902 ft.

TEXAS GULF COAST COMPLETIONS

Wildcats

Chambers County: Sun 1 C. Doornbos, T.&N.O. Sur., Sec. 83, Fig Ridge area, 139 bbl. through ⅛-in. choke, T.P. 1,000 lb., C.P. 200 lb., gas-oil ratio 585:1, perf. 8,214-22 ft., T.D. 8,340 ft.

Harris County: A. T. McDannald et al 2 East Texas Oil Co., Victor Blanco Sur., dry at 4,515 ft., no shows encountered.

Liberty County: Hebert & Smith 1 G. W. Conger, John Blair Sur., junked at 7,243 ft.

Fields

Lolita, Jackson County: Tide Water 1 L. Ranch, 121 bbl through ⅛-in. choke, T.P. 625 lb., C.P. 900 lb., T.D. 5,946 ft., old well drilled deeper.

Maurbro, Jackson County: Humble 1 Fred S. Robbins, 50 bbl. through ¼-in. choke, T.D. 100 lb., C.P. 900 lb., T.D. 5,227 ft.

North La Ward, Jackson County: Cities Service 1 V. Orsog, 3 bbl. 1 hr. through ⅛-in. choke, T.P. 440 lb., C.P. 800 lb., T.D. 6,317 ft., P.B. to 6,290 ft.

Lovells Lake, Jefferson County: Humble 40 Broussard Trust Co., plugged and abandoned at 6,883 ft.

Humble 1 Jefferson Land Co., 186 bbl. through ⅛-in. choke, T.P. 1,200 lb., C.P. 1,325 lb., T.D. 7,791 ft.

OKLAHOMA FIELD REPORT

Viola Production Found in East Beebe Area

By CARL HOOT

OKLAHOMA had a rather unusual week with seven wildcats and six pool wells completed. Greater activity was indicated for southern Oklahoma with four wildcats finished in as many counties.

A relatively large Viola lime discovery in Pontotoc County was completed for 314 bbl. of 38-gravity crude last week. W. A. Delaney 1 Roper, NW NW 26-5n-5e, topped the lime at 2,453 ft., with pay coming from 2,505-52 ft. At this depth a drill-stem test recovered 150 ft. of oily mud but after a 3,000-gal. acid treatment a number of swabbing tests were made, one of which produced 425 bbl. of oil in 15 hours. Location of the well is between the Bebee and Wetley pools. Production in the Bebee and East Bebee areas, discovered in 1930, is from Senora sand, the Hunton, Viola and Simpson zones.

In Payne County, Phillips Petroleum Co. added another well to its new Hunton lime pool discovered in May of this year. Offsetting the discovery, 1 School Land, to the northwest, its 1 Loco, NW NE 36-18n-1e, pumped 96 bbl. of oil a day in Hunton lime at 4,747 ft.

Wildcats

Atoka County: H. F. Potts 1 Kinch, NW SW SE 18-3s-10e, dry, T.D. 1,350 ft., stain in sandy lime at 1,260-68 ft., 500,000 cu. ft. gas.

Caddo County: Texas 2 Tishecoddy, NE cor. 26-5n-11w, dry, T.D. 2,275 ft.

Texas 1 Wer-Yack-We, NE NW NW 28-5n-11w, dry, T.D. 1,973 ft.

Jackson County: Lloyd Noble 1 Gregory, SE NW 36-1s-24w, dry, T.D. 7,504 ft. ⅛

Kiowa County, 10 mi. SW of Hobart: Tide Water and Skelly 1 Smith, NW SW SE 23-7n-20w, dry, T.D. 1,800 ft., black granite 1,665 ft.

Murray County: Rogers Bros. 1 Vanderslice, NW NW SE 25-2n-2e, dry, T.D. 2,590 ft., sand 1,495 ft.

Pontotoc County: W. A. Delaney 1 Roper, NW NW 26-5n-5e, pumped 314 bbl., Viola 2,505-52 ft., discovery.

Stephens County: T. H. McCasland 1 Semple, SW SE NW 29-1n-5w, dry, T.D. 2,502 ft.

Fields

Edmond, Northeast, Oklahoma County: Harper-Turner 1 Wilson, SE NE 18-14n-2w, flowed 37 bbl., sand 5,845 ft., T.D. 5,890 ft.

(Continued on Page 259)

Additional Prospects Sought In Los Angeles City Limits

By L. P. STOCKMAN

LOS ANGELES, Calif.—The success of Shell Oil Co., Inc., in securing permission to drill a deep test in the Gilmore Island section in the Wilshire district of Los Angeles has started prospectors in search of suitable areas within the city in which to drill. With the precedent established by the granting of Shell of drilling variances and the awarding of pipe-line rights in the Salt Lake-Gilmore Island area, other operators are hopeful that comparable permits will be granted in other sections of the city. Golf courses which are losing money in continued operation have become prime possibilities provided they are located in suitable locations where structural conditions are favorable. Geologists have always been of the opinion that a major field lies below the city of Los Angeles and could be reached provided drilling operations were possible. Until the present emergency there has been a general feeling that all drilling within the city limits should be prohibited and there is on the statute books an ordinance prohibiting all such drilling except where special permission is granted. This ordinance was passed a couple of years ago to specifically prevent any operator from taking over some of the many small wells within the city and redrilling and deepening them to a possible lower zone. In certain localities there is a possibility of deepening some of these old wells that are far enough removed from dwellings so as not to cause any great noise. In order to eliminate obnoxious noises as far as possible, electrically drilled holes or diesel-butane driven equipment may be used. In addition and as far as possible, work will be done during daylight hours in order not to disturb the slumbers of defense employes who might be on daylight hours. After completion of the discovery well, however, this condition would be remedied by construction of a soundproof building that would kill most of the noise resulting from drilling operations.

A careful search is being made to determine how many promising areas are located within the city and in which drilling could be done with these least inconvenience. Most of the possible locations available for work are limited in areal extent and therefore any future drilling within the city's metropolitan district must be for the most part by directional drilling. This should prove helpful, however, as it will give the operator a chance to take into the general scheme of things all surrounding acreage in a community lease and thus permit greater deviations from the vertical. In addition to thus enlarging the amount of subsurface acreage available for development, this forming of community leases would eliminate or remove much objections to such work. Developments during the next few weeks should determine whether operators consider the possibilities good enough to justify the necessary outlay to secure passage of the needed legislation.

Work Progresses at New Pools

In the two latest discoveries in Los Angeles Basin, Buena Park in Orange County and Turnbull Canyon in Los Angeles County, development work is proceeding along conservative lines. The Texas Co. is nearing completion depth in 4-1-F at Buena Park in 36-3s-11w and should be ready to test this well within the next 2 or 3 weeks. This new well is located upstructure from the most westerly producing well and should result in pumping production. Paradoxical as it may seem, the lowest well structurally in the Buena Park field is the largest producing well in the field and the well located highest on the structure failed to show commercial production. The Buena Park structure is a plunging nose and is plunging toward Santa Fe Springs where great thicknesses of oil sands were encountered during drilling. The productive zone at Buena Park is the probable equivalent of the Bell at Santa Fe Springs. Turnbull Canyon, like Buena Park, has not yet shown substantial sustained production although one well came in flowing around 1,000 bbl. per day. When first discovered, Turnbull Canyon was thought to be a field of large magnitude but subsequent development work has restricted the areal extent and indicated that production will not be large.

Heavy Crude From Shallow Wells Needed

A meeting of Wilmington operators interested in additional drilling will hold a meeting within the next few days to find out what has happened to specific requests for exceptions for shallow wells in the Wilmington field. Some time ago it appeared that the necessary exceptions would be granted but for some reason such has not been the case. Operators would like to be able to drill about 100 new wells to the Ranger tar zone and possibly into the upper Terminal zones in order to step up production of heavier grades of crude oil. This would be in conformity with recommendations contained several months ago in the survey conducted by the California office of OPC. The most productive section of the Wilmington field where operators would like to drill new shallow wells is in the Long Beach Harbor section. Union Pacific Railroad would be able to drill at least 50 shallow-zone wells if permission is granted as this company's large fee-owned acreage is only partly developed as far as the tar zone and Ranger sand are concerned. Many of this company's completed wells were finished in the upper and lower Terminal zones which are more prolific than the tar and Ranger sands. Unless there is some definite demand, the Ford zone of Miocene age in the Wilmington field will be held back indefinitely. This zone, originally found by General Petroleum Corp. in a well drilled on property of Ford Motor Co., has not been produced in the Long Beach Harbor section of the field, where it is expected to prove a zone of high productivity. In the town-lot section to the west, the Ford zone has only proved of secondary importance, principal production coming from the Ranger.

LOS ANGELES BASIN COMPLETIONS

Brea Olina, Orange County: Union Oil Co. 74 Stearns, 7-3s-9w, pumped 107 bbl., 24.4-gravity, T.D. 4,295 ft., P.B. 4,020 ft., perf. 3,233-3,572 ft., 3,694-4,018 ft., upper zone of Pliocene age.

Torrance, Los Angeles County: Wood-Callahan Oil Co. 3 Dominguez Estates, 5-4s-14w, pumped 74 bbl., 14.4-gravity, T.D. 3,675 ft., perf. 3,300-3,670 ft., completed in equivalent of Ranger zone of Pliocene age.

Wilmington, Los Angeles County: Texas Co. 5 Refinery fee, 27-4s-13w, pumped 54 bbl., 14.6-gravity, T.D. 3,505 ft., perf. 3,351-3,496 ft., Ranger zone of Pliocene age.

SAN JOAQUIN VALLEY

Drilling operations in San Joaquin Valley fields showed a substantial increase during September and resulted in completion of numerous new wells. These new producers were, for the most part, located in fields where shallow drilling is possible and which produce a heavy grade of crude oil. Completions were especially numerous in the South Belridge field and also at Midway-Sunset. Many of the current completions were finished in from 5 to 6 drilling days' time from spud to completion. This is especially true of wells drilled to 750-1,000-ft. sands as the actual time spent in drilling was not over 3 days with the balance spent in finishing and hooking up lead lines and installing pumping equipment. This shallow drilling is done almost entirely with portable equipment and for this reason not much time is lost between wells. There should be no decline in the amount of new drilling in shallow fields in the near future as locations have been staked for approximately 150 new wells in San Joaquin Valley fields. This new drilling will probably be stretched out over the next 2 or 3 months but from present indications the completion of about 100 new wells in San Joaquin Valley fields between now and the end of the year may be expected.

SAN JOAQUIN VALLEY COMPLETIONS

Antelope Plains, Kern County: Shell Oil Co. 35-6 Williams, 6-28s-20e, flowed 211 bbl., 16-gravity, T.D. 2,559 ft., P.B. 2,340 ft., perf. 2,235-2,335 ft., Williams zone of Miocene age.

Belridge, South, Kern County: Belridge Oil Co. 38-34 fee, 34-28s-21e, pumped 25 bbl., 14.8-gravity, T.D. 775 ft., perf. 399-574 ft., 601-706 ft., 729-75 ft., upper zone of Pleistocene age.

Belridge Oil Co., 48-34 fee, 34-28s-21e, pumped 40 bbl. 15.6-gravity, T.D. 792 ft., perf. 365-445 ft., 506-75 ft., upper zone of Pleistocene age.

Belridge Oil Co. 58-34 fee, 34-28s-21e, pumped 15 bbl., 15.6-gravity, 50 per cent cut, T.D. 800 ft., P.B. 698 ft., perf. 482-698 ft., upper zone of Pleistocene age.

Belridge Oil Co. 66-33 fee, 33-28s-21e, pumped 70 bbl., 15.1-gravity, T.D. 775 ft., perf. 375-577 ft., 625-60 ft., 681-717 ft., upper zone of Pleistocene age.

Belridge Oil Co. 68-34-A fee, 34-28s-21e, pumped 20 bbl., 14.9-gravity, T.D. 800 ft., P.B. 561 ft., perf. 429-561 ft., upper zone of Pleistocene age.

General Petroleum Corp. 13-A fee, 3-29s-21e, pumped 74 bbl., 14.8-gravity, 50 per cent cut, T.D. 925 ft., perf. 531-73 ft., 604-732 ft., 772-914 ft., upper zone of Pleistocene age.

General Petroleum Corp. 29-A fee, 3-29s-21e, pumped 86 bbl., 15.1-gravity, T.D. 1,005 ft., perf. 579-780 ft., 802-910 ft., 932-1,000 ft., upper zone of Pleistocene age.

General Petroleum Corp. 30-A fee, 3-29s-21e, pumped 46 bbl., 15.9-gravity, T.D. 1,000 ft., perf. 642-70 ft., 714-90 ft., 825-924 ft., 946-76 ft., upper zone of Pleistocene age.

General Petroleum Corp. 37 fee, 3-29s-21e, pumped 92 bbl., 15-gravity, T.D. 858 ft., perf. 501-44 ft., 566-670 ft., 740-851 ft., upper zone of Pleistocene age.

General Petroleum Corp. 76-A fee, 3-29s-21e, pumped 5 bbl., 14.9-gravity, T.D. 1,112 ft., P.B. 1,010 ft., perf. 702-40 ft., 855-65 ft., 94-1,000 ft., upper zone of Pleistocene age.

Ohio Oil Co. 4 Emily Hopkins fee, 4-29s-21e, pumped 78 bbl., 13.5-gravity, T.D. 848 ft., perf. 477-837 ft., upper zone of Pleistocene age.

Coalinga, East, Fresno County: Shell Oil Co. 77-29 fee, 29-19s-15e, pumped 291 bbl., 16.9-gravity, T.D. 2,730 ft., perf. 2,600-53 ft., 2,668-2,729 ft., upper zone of Pliocene age.

Standard Oil Co. 106-35-A fee, 35-19s-15e, pumped 71 bbl., 20.4-gravity, T.D. 3,022 ft., P.B. 2,972 ft., perf. 2,855-2,968 ft., second zone of Pliocene age.

Coalinga, West, Fresno County: Section 30 Oil Co. 10 Coalinga, pumped 15 bbl., 19.8-gravity, T.D. 1,255 ft., perf. 1,145-1,255 ft., upper zone of Pliocene age.

Helm, Fresno County: Amerada Pet. Corp. 41-2 Hatch, 2-17s-17e, flowed 201 bbl., 59.2-gravity, 3,600,000 cu. ft. gas, T.D. 8,072 ft., perf. 7,892-8,010 ft., Temblor 5,890 ft., Kreyenhagen 7,605 ft., Eocene sand 7,982-8,072 ft.

Jacalitos wildcat district, Fresno County: Texas Co. 1 Ferguson, 32-21s-16e, abandoned in gray sand and shale, T.D. 7,214 ft., McClure 6,118 ft., Temblor 6,242 ft., Kreyenhagen 7,170 ft., test with packer at 7,071 ft., recovered 6,000 ft. of salt water.

Kern River Front, Kern County: General Pet. Corp. 1 Young, 14-28s-27e, pumped 84 bbl., 13.9-gravity, T.D. 1,996 ft., P.B. 1,970 ft., perf. 1,876-1,969 ft., Tegeler zone of Pliocene age.

Standard Oil Co. 28-15 fee, 15-28s-27e, pumped 70 bbl., 14.1-gravity oil and 110 bbl. water, T.D. 2,630 ft., perf. 2,407-2,532 ft., M point 2,203 ft., N point 2,304 ft., Tegeloer zone of Pliocene age 2,516-2,630 ft.

McKittrick, Kern County: Tide Water 65 Del Monte, 13-30s-21e, pumped 60 bbl., 15.5-gravity, T.D. 1,125

ft., perf. 54-71 ft., McKittrick zone of Pliocene age.

Midway-Sunset, Kern County: Chanslor-Canfield Midway Oil Co. 38-22 fee, 22-31s-22e, pumped 3 bbl., 11.5-gravity oil and 7 bbl. water, T.D. 1,791 ft., P.B. 1,632 ft., perf. 1,133-1,632 ft., upper zone of Pliocene age.

Richfield Oil Corp. 7 Belgian, 3-31s-22e, pumped 65 bbl., 14.1-gravity, T.D. 1,300 ft., perf. 1,094-1,298 ft., upper zone of Pliocene age.

Standard Oil Co. 100-33-D fee, 33-32s-24e, pumped 218 bbl., 22.6-gravity, T.D. 3,130 ft., perf. 3,042-3,128 ft., Lakeview zone of Pliocene age.

Standard Oil Co. 102-7-D fee,. 7-32s-24e, pumped 55 bbl., 25.9-gravity, T.D. 2,905 ft., perf. 2,600-2,850 ft., upper zone of Pliocene age.

Mount Poso, Kern County: Chanslor-Canfield Midway Oil Co. 7 Mon, 26-27s-28e, pumped 86 bbl., 15.8-gravity, T.D. 1,577 ft., perf. 1,514-77 ft., Vedder zone of Miocene age, 1,531-77 ft.

Riverdale, Fresno County: Amerada Pet. Corp. 58-23-F Hancock 23-17s-19e, flowed 605 bbl., 36.3-gravity, T.D. 6,900 ft., P.B. 6,864 ft., perf. 6,840-62 ft., McClure 5,294 ft., Temblor 5,580 ft., top 68 zone of Miocene age 6,837 ft.

Round Mountain, Kern County: Honolulu Oil Corp. 1-D, 18-28s-29e, pumped 262 bbl., 14.7-gravity, 50 per cent cut, T.D. 1,862 ft., perf. 1,812-56 ft., Vedder zone of Miocene age 1,808-62 ft.

Shell Oil Co. 22 Caldwell, 7-28s-29e, pumped 215 bbl., 15.1-gravity, T.D. 2,070 ft., perf. 2,040-70 ft., Vedder zone of Miocene age, 2,043-70 ft.

Shell Oil Co. 1-12 Olcese, 21-28s-29e, pumped 21 bbl., 22.4-gravity, T.D. 1,745 ft., perf. 1,204-1,645 ft., Vedder zone of Miocene age.

COASTAL DISTRICT

R. E. Havenstrite, who recently found a new deeper productive zone in 2 Barnes in the Del Valle field, is at present drilling ahead at 8,755 ft. and may go to 9,000 ft. before plugging back to the new zone for a production test. The new sand found probably correlates with the Porter sand at Aliso Canyon and with the deep sand found by Western Gulf Oil Co. in the Oak Canyon field. All three of these zones are in rocks of Miocene age, possibly middle or lower Miocene. Very little sand has been cored in 2 Barnes since passing through the new zone which may be termed the Barnes sand in this field. For this reason it may be possible that another zone may be found in 2 Barnes before drilling operations are concluded. The Del Valle, San Martinez, Oak Canyon, Aliso Canyon and Newhall Potrero fields are carried with the coastal district group because in Los Angeles County they definitely correlate with conditions found in adjacent Ventura County and are technically outside the generally accepted geographical limitations of Los Angeles Basin. In the Alison Canyon field, Tide Water Association Oil Co. has taken 1 Sesnon off production at 8,912 ft. and has redrilled to 8,539 ft. where 7-in. casing has been landed. Preparations are now under way to drill ahead. This well failed to show favorable production although it did make a good gas showing. In the Newhall Potrero field, Barnsdall Oil Co. has completed 32 Rancho San Francisco, an offset to 1 Ferguson of C. G. Willis and associates, and production is still cleaning up.

COASTAL DISTRICT COMPLETIONS

San Martinez, Los Angeles County: Ohio Oil Co. 4 Vasquez, 17-4n-17w, flowed 240 bbl., 59.7-gravity, 7,000,000 cu. ft. gas, T.D. 5,892 ft., perf. 5,425-60 ft., 5,580-5,640 ft., Videgain oil sand of Pliocene age, capable of greatly exceeding initial.

Standard Oil Co. 4 Sepulveda, 17-4n-17w, flowed 2,304 bbl., 35.5-gravity, T.D. 5,674 ft., perf. 5,549-5,673 ft., 5,340-60 ft., Videgain oil sand of Pliocene age.

Santa Maria Valley, Santa Barbara County: Hancock & Bush 4 Rosenblum, 25-10n-34w, flowed 892 bbl., 14.4-gravity, T.D. 4,680 ft., perf. 3,725-4,680 ft., Monterey of Miocene age.

Illinois Fields

(Continued from Page 252)

win, NE SE SW 11-8s-10e, pumped 177 bbl., sand 2,039-57 ft., 40-qt. shot 2,048-57 ft., T.D. 2,057 ft.

Geff, Wayne County: Pure 3 Atteberry, SW SE NE 11-1s-7e, pumped 28 bbl., Aux Vases 3,082-99 ft., T.D. 3,145 ft.

Hoodville, Hamilton County: Eason Oil 1 Hogan, NW SW SE 4-6s-6e, dry at 3,232 ft., Benoist 2,915 ft., Aux Vases 3,089 ft., Ste. Genevieve 3,120 ft.

Irvington, Washington County: Magnolia 5 Koelling, NE SE NE 15-1s-1w, pumped 21 bbl., Bethel 1,518 ft., 10-qt. shot 1,542 ft., T.D. 1,546 ft.

Magnolia 6 Koelling, NW SE NE 15-1s-1w, pumped 18 bbl., 10-qt. shot 1,535-39 ft., Benoist 1,535-39 ft., T.D. 1,539 ft.

Louden, Fayette County: Carter 6 Rhedemeyer, NW SW NE 3-8n-3e, dry at 1,531 ft.,

Carter 2 Alsop, NW SW SE 3-8n-3e, flowed 120 bbl., Weiler 1,504 ft., 20-qt. shot 1,514 ft., T.D. 1,531 ft.

Mount Erie, Wayne County: Pure 2 Allen, W½ NW SE 2-1s-8e, dry at 3,200 ft., McClosky 3,105 ft.

New Harmony, White County: Superior 42 Fitten, SW SW SW 14-4s-14w, pumped 135 bbl., 20-qt. shot 2,235 ft., Waltersburg 2,144 ft., T.D. 2,663 ft.

Superior 3 Lomas, SW NE SW 14-4s-14w, pumped 135 bbl., 5-qt. shot 2,234 ft, Waltersburg 2,121-34 ft., T.D. 2,243 ft.

Noble, Richland County: Carter 2 Winters, SW NW 10-3n-9e, pumped 206 bbl., natural, sand 2,584-87 ft., T.D. 2,588 ft.

North Boos, Jasper County: Pure 1-A Swick, SE NW 20-6n-10e, flowed 748 bbl., 5,000 gal. acid, Rosiclare 2,807 ft., T.D. 2,858 ft.

Olney, Richland County: J. W. Menhall 1 Miller, SW NE SW 27-4n-10e, pumped 7 bbl., 5,000 gal. acid, McClosky 3,044-47 ft., T.D. 3,100 ft.

Phillipstown, White County: Hollingsworth 1 Renshaw, NW SE NE 1-5s-10e, pumped 95 bbl., sand 2,274 ft., T.D. 2,328 ft.

Roland, White County: Kingwood 2 Clow, NW NE SW 12-7s-8e, pumped 67 bbl., 10-qt. shot 2,205 ft., Waltersburg 2,201 ft., T.D. 2,219 ft.

Magnolia 4 General American Life, SW NE SW 1-7s-8e, pumped 110 bbl., 10-qt. shot 2,232 ft., Waltersburg 2,220 ft., T.D. 2,241 ft.

Rural Hill, Hamilton County: Magnolia 10 Sloan, SW NE SE 23-6s-5e, pumped 70 bbl., Aux Vases 3,101 ft., 10-qt. shot, T.D. 3,113 ft.

South Lawrence, Lawrence County: Jablonski 2 Tanquary, NW NW NW 35-2n-12w, pumped 50 bbl., Benoist 2,010 ft., 30-qt. shot 2,017-28 ft., T.D. 2,028 ft.

S. R. Nye 1 Catt, SW SW SE 23-2n-12w, pumped 35 bbl., Biehl 1,335 ft., T.D. 1,400 ft.

Olds et al 4 Van Wey, SW NE SE 23-2n-12w, pumped 200 bbl., Biehl 1,350-82 ft., T.D. 1,382 ft.

Sam Malis 1 Ireland, SW SE NW 27-2n-12w, pumped 70 bbl., 20-qt. shot on bottom, Benoist 1,995 ft., T.D. 2,005 ft.

South Maunie, White County: Magnolia 16 Sisson-Higgins, SE SW SE 24-6s-10e, pumped 20 bbl., 20-qt. shot 2,261-69 ft., sand 2,253 ft., T.D. 2,273 ft.

Baldwin, Barrett & Misener Drlg. 8-C Pool, SE NE NW 13-6s-10e, pumped 146 bbl., Palestine 2,003-22 ft., T.D. 2,210 ft.

South Sailor Springs, Clay County: W. C. McBride 1 Franklin, SE SE SW 3-3n-7e, pumped 65 bbl., Cypress 2,582-2,614 ft., T.D. 2,614 ft.

Walpole, Hamilton County: Texas 1 Irvin, W½ NW NW 26-6s-6e, dry at 3,136 ft., Aux Vases 3,084 ft., Ste. Genevieve 3,135 ft.

Miscellaneous, Hamilton County: Texas 3 Minton, NE NW SW 21-4s-7e, dry at 3,480 ft., Aux Vases 3,312 ft., Ste. Genevieve 3,334 ft.

Texas 1 Ernst, E½ NW NW 21-4s-7e, flowed 212 bbl., Aux Vases 3,270 ft., McClosky 3,415 ft., T.D. 3,501 ft.

Eastern Kentucky

(Continued from Page 254)

Cable, on the Lenox Brewer operation on Little Sinking, has reached the 800-ft. level. This is the first report of activity from that county in recent weeks.

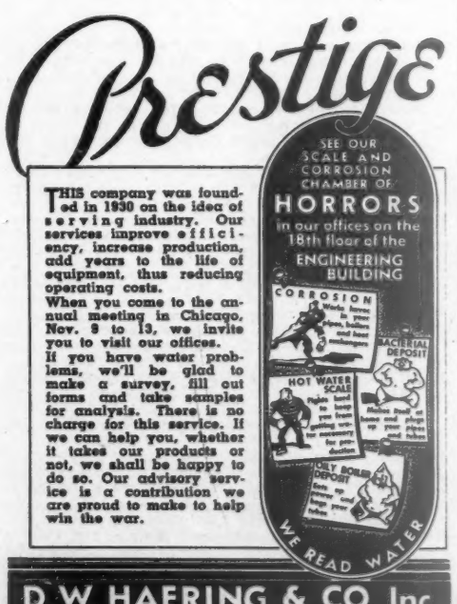
EASTERN KENTUCKY COMPLETIONS

Johnson County: Inland Gas Corp. 238 Jesse Horne, Rockhouse Creek, 190,000 cu. ft. gas, T.D. 2,430 ft. in Big Six sand.

Magoffin County: Bed Rock Pet. 14 Patton Borders tract near Oil Springs, est. 5 bbl. production.

Martin County: Kentucky-West Virginia Gas 5423 Phillip Preece land, Coldwater Fork, dry at T.D. 3,010 ft. in shale.

Gotkool
WATER CANS
& COOLERS
GOTT Water Cans are the practical way to keep drinking water cool for long periods, protected from impurities and always handy to the job. Snug fitting large removable top, strongly built to withstand rough usage. GOTT Water Coolers have extra large covers and a handy non-leaking push button faucet. Your Supply Store has them, get one today!
GOTT
GOTKOOL WATER CAN
Made in 1, 2, 3, 5, 10, 15 and 20 gallon sizes. Furnished with push button faucet at slight additional cost.
GOTKOOL WATER COOLER
Made in 2, 3, 5, 8, 10, 15 and 20 gallon sizes
H. P. GOTT MFG. CO.
WINFIELD, KANSAS
KEEP PURE DRINKING WATER ALWAYS HANDY


Prestige
THIS company was founded in 1930 on the idea of serving industry. Our services improve efficiency, increase production, add years to the life of equipment, thus reducing operating costs.
When you come to the annual meeting in Chicago, Nov. 9 to 13, we invite you to visit our offices.
If you have water problems, we'll be glad to make a survey, fill out forms and take samples for analysis. There is no charge for this service. If we can help you, whether it takes our products or not, we shall be happy to do so. Our advisory service is a contribution we are proud to make to help win the war.
SEE OUR SCALE AND CORROSION CHAMBER OF HORRORS in our offices on the 18th floor of the ENGINEERING BUILDING
CORROSION
BACTERIAL DEPOSIT
HOT WATER SCALE
BOILER DEPOSIT
WE READ WATER
D. W. HAERING & CO., Inc.
GENERAL OFFICES 205 West Wacker Drive
Chicago Illinois

IF YOU USE ROPE
THESE 54 WORDS
MAY INTEREST YOU
Into "Topsall" treated sisal go only the finest available fibres. Before being laid into rope the fibres are combed, treated and lubricated by the exclusive New Bedford method which not only makes "Topsall" rugged, flexible and long lasting, but also protects it against rot and decay. "Topsall" handles right—does not kink or swell.
NEW BEDFORD CORDAGE COMPANY
233 Broadway New York, N. Y.
230 W. Huron St. Chicago, Ill.
Mills: New Bedford, Mass.
2751

NORTH LOUISIANA, ARKANSAS

New Gas Field Opened In Arkansas River Valley

SHREVEPORT, La.—A large gas well was brought in last week in Pope County, northern Arkansas, when Arkansas Louisiana Gas Co.'s wildcat, 1 Ladd & Strong, NE SW SW 22-10n-21w, flowed 26,000,000 cu. ft. of gas a day from sands at 2,475-2,512 ft. and 2,802-17 ft. Total depth was 2,830 ft. The well is located near the small town of Silex and some 15 miles east of Clarksville in Johnson County.

Other wildcat operations of interest were in the New London area of Union County. On the north edge of the field, Union Saw Mill 4 Frost was reported to have found favorable showings at 5,800 ft. and had set casing at that depth.

NORTH LOUISIANA COMPLETIONS

Catahoula Lake, La Salle Parish: Carter Oil 2-A Tensas Delta, SE SW 25-6n-4e, flowed 150 bbl., pay 4,572-75 ft., T.D. 5,976 ft., workover.

Caddo, Caddo Parish: W. T. Bell 1 Thigpen-Herold, NE SW SW 34-22n-16w, pumped 10 bbl., T.D. 2,460 ft.

Bayou State Oil 3-A Brown, NW SW SE 21-22n-15w, pumped 5 bbl., T.D. 1,047 ft.

Georgetown, Grant County: Placid Oil 2-B Tremont, SW NW 10-9n-1e, pumped 54 bbl., pay 1,528-34 ft.

Placid Oil 4-B Tremont, SE SW 10-9n-1e, dry, T.D. 1,614 ft.

Haynesville, Claiborne Parish: Ohio Oil 1 Seagers 4-P, SW SW 3-23n-8w, flowed 425 bbl., Pettit 5,315-29 ft., 5,375-84 ft., T.D. 5,421 ft.

Phillips Pet. 1 Silas, NE SW 12-23n-8w, flowed 194 bbl., Pettit 5,297-5,312 ft., T.D. 5,380 ft.

Monroe, Union Parish: Interstate Natural Gas 120 fee, C SE 13-21n-3e, 8,784,000 cu. ft. gas, T.D. 2,166 ft.

Interstate Natural Gas 122 fee, 2,706 ft. S of NE cor. 12,424,000 cu. ft. gas, T.D. 2,195 ft.

Nebo, La Salle Parish: Placid Oil 1 Walker, NW SW NW 2-7n-3e, dry, T.D. 4,438 ft.

Sligo, Bossier Parish: Triangle Drlg. 2-C Thigpen-Herold, NW SW 19-17n-11w, pumped 45 bbl., pay 3,166-68 ft., T.D. 3,180 ft.

ARKANSAS COMPLETIONS

Wildcat, Calhoun County: Placid Oil 1 Furlow-Abbott, SW SW 28-14s-14w, dry, T.D. 4,995 ft.

Wildcat, Pope County: Arkansas Louisiana Gas Co. 1 Ladd & Strong, NE SW SW 22-10n-21w, 26,000,000 cu. ft. gas, pay 2,475-2,512 ft., 2,802-17 ft., T.D. 2,830 ft.

Fouke, Miller County: Carter Oil 10 Sturgis, SE SW NW 1-17s-27w, flowed 528 bbl., pay 3,694-3,705 ft., T.D. 3,877 ft.

McKamie, Lafayette County: Frankel Bros. & Riddell 1 Oliver & Layne, C SW 31-17s-23w, dry, T.D. 9,639 ft.

Macedonia, Columbia County: Magnolia 1 Franks-Norwood, W½ NE SE 16-18s-21w, pumped 50 bbl. condensate, T.D. 8,914 ft., workover.

Magnolia 1 Willis unit, C N½ SE 17-18s-21w, pumped 50 bbl. condensate, T.D. 8,935 ft., workover.

Permian Basin-Panhandle

(Continued from Page 251)

PANHANDLE COMPLETIONS

Fields

Gray County: Magnolia Pet. 55 fee-227, Sec. 14, Blk. 3, H.&G.N. Sur., elev. 2,891 ft., potential 94 bbl., pay 2,780 ft., shot 440 qt., T.D. 2,895 ft.

Phillips Pet. 1 Eakin, Sec. 20, Blk. B-2, H.&G.N. Sur., elev. 3,298 ft., 5,200,000 cu. ft. gas, acid 1,300 gal., T.D. 3,131 ft., P.B. 2,918 ft.

Skelly 3 East-Jackson, Sec. 62, Blk. B-2, elev. 3,074 ft., dry, T.D. 3,310 ft.

Hutchinson County: J. E. Crosbie 50 Pitts, Sec. 7, Blk. M-21, elev. 2,839 ft., potential 208 bbl., pay 2,730 ft., shot 480 qt., T.D. 2,830 ft.

A. C. Oates 6 Starnes, Sec. 24, Blk. M-23, elev. 3,215 ft., potential 54 bbl., pay 3,054 ft., shot 940 qt., T.D. 3,175 ft.

SOUTHEAST NEW MEXICO

HOBBS, N. M.—An increase in wildcat activity was noted last week in Southeast New Mexico. A number of new wildcat locations have also been announced recently. An important wildcat was scheduled for northeastern Lea County when Malco Refining Co. staked location for its 1 Bilberry, SE SW SW 1-7s-37e, a 5,000-ft. test located about 3 miles northwest of the Slaughter-Duggan field in West Texas.

In this same area, 3 miles directly south of the Bilberry test, Ohio Oil Co. was still trying to make a well out of its 1 State-McCormick, 36-9s-37e, but had only a showing of heavy black oil. The rig has been moved off but flowing tests were still being made late last week. Flowing through open tubing against 625 lb. casing pressure, with gas volume estimated up to 500,000 cu. ft. of gas a day, it produced 8 bbl. in 4 hours of fluid which was mostly salt water and sediment. Total depth was 5,658 ft., 7 ft. in the Glorietta sand. The well was then plugged back to 4,993 ft. where it was acidized with 5,000 gal.

The Square Lake pool of Eddy County, which has been the most active field in the state recently, had prospects of a ¾-mile extension when Premier Petroleum Corp. 1 Stablein found a slight showing of oil at 2,875-80 ft. in lime. Drilling continued and on last report it was below 3,075 ft.

SOUTHEAST NEW MEXICO COMPLETIONS

Wildcat, Lea County: Davidson & Clower 1 Shell-State, NE NE 20-21-34e, dry, T.D. 4,130 ft.

Square Lake, Eddy County: Max Coll & Carper Drlg. 1 State, SW NE 36-16s-30e, flowed 100 bbl., natural, pay 3,010-50 ft., T.D.

Carper Drlg. 2 Tellyer-State, NW NE 36-16s-30e, flowed 72 bbl., pay 2,900-3,134 ft., shot.

Oklahoma Fields

(Continued from Page 256)

Garber, Garfield County: Sinclair Prairie 23-C Crews, W½ NW SE 19-22n-3w, pumped 10 bbl., sand 1,955-77 ft., 2,122-31 ft., perforated and pumped both zones.

Oklahoma City, Oklahoma County: C. C. Peppers 1 Blk. 2, SE SW SW 27-12n-3w, pumped 154 bbl., Simpson 6,425 ft., Wilcox 6,453 ft., T.D. 6,536 ft.

St. Louis, North, Pottawatomie County: C. J. Bucy 1 Reed, NE NE SW 20-8n-4e, pumped 16 bbl., Hunton 4,411 ft., T.D. 4,866 ft.

Miscellaneous

Hughes County: Otha Grimes 1 Barnett, SE SW SE 24-8n-10e, 1,750,000 cu. ft. gas, Gilcrease 2,813-42 ft., shot, P.B. 2,830 ft.

Payne County: Phillips 1 Loco, NW NE 36-18n-1e, pumped 96 bbl., Hunton 4,747 ft., T.D. 4,755 ft.

North Central Texas Fields

(Continued from Page 253)

ft., acid 7,000 gal., T.D. 4,842 ft.

Steed-Worsham, Jack County: Joe A. Worsham 1 L. W. Carney, I. Farris Sur. A-220, location abandoned.

Sanders, Montague County: Sinclair Prairie 1 Ella McCarty, Blk. 114, J. C. Mattison Sur. A-471, dry, T.D. 6,860 ft.

K.M.A. Ellenburger, Wichita County: E-C Oil Co. 31-E Mrs. Anna Mangold, Lot 32, P. Castleman Sur. A-35, location abandoned.

E-C Oil Co. 32-E Mrs. Anna Mangold, Lot 32, P. Castleman Sur. A-35, pumped 139 bbl. oil and 50 bbl. water per day, pay 4,368 ft., acid 6,000 gal., T.D. 4,390 ft.

Street, Young County: Hanlon-Buchanan, Inc. 1 H. B. Street et al, J. Conner Sur. A-57, dry, T.D. 4,901 ft.

WEST CENTRAL TEXAS COMPLETIONS

Wildcats

Coleman County: Woodley Pet. Corp. 1 R. M. Burroughs, Sec. 2, Blk. 1, H.T.&B. Sur., dry, T.D. 3,454 ft.

Fields

Triplett, Jones County: T. D. Humphrey 2 Mary Rust, J. V. Hughes Sur. 256, dry, T.D. 2,920 ft.

Akard, Jones County: Ungren & Frazier 3-A Dorothy Akard, G. Martinez Sur. 137, flowed 106 bbl., ¾-in. choke, shot 20 qt., pay 2,128 ft., T.D. 2,133 ft. lime.

Wimberly, Jones County: Fain-McGaha 2 L. L. Horne, G. Martinez Sur. 137, flowed 342 bbl., ⅝-in. choke, natural, pay 2,226 ft., T.D. 2,233 ft.

Clark & Cowden 2 W. R. Washburn, Lot 85, Godwin subd. of De Witt C.S.L. Sur. 126, flowed 544 bbl., ¾-in. choke, acid 3,000 gal., pay 2,317 ft., T.D. 2,330 ft.

Shackelford field, Shackelford County: A. B. Schadke 3 J. L. Goodwin, Sec. 385, T.E.&L. Sur., location abandoned.

Eastern Texas

(Continued from Page 255)

EAST TEXAS BORDER COMPLETIONS

Wildcats

Shelby County: E. E. Hurley et al 1 Frost Lumber Co., W. M. Waterman Sur., 10 mi. SW of Center, elev. 465 ft., dry, T.D. 6,786 ft.

Fields

Carthage gas field, Panola County: Glassell & Glassell 4 Frost Lumber Co., P. Martin Sur., dual completion; set packer at 5,800 ft., tested 14,000,000 cu. ft. gas, open flow, est. 16 bbl. distillate per million, R.P. 2,221 lb., from Rodessa pay zone; tested 7,000,000 cu. ft. gas, open flow, est. 10 bbl. distillate per million, from Pettit lime zone, T.D. 5,975 ft.

Thomason & Turner 1 Silas Hudson, E. Decker Sur., potential 12,350,000 cu. ft. gas, open flow, R.P. 2,406 lb., T.D. 6,494 ft.

MICHIGAN OPERATIONS

Slight Pickup Recorded in Operations Last Week

By OTTO C. PRESSPRICH

SAGINAW, Mich.—Michigan oil operations stepped up last week, operators listing 16 completions, including a good Osceola County well, another deep hole producer in Roscommon County and four other smaller producers. There were two natural-pas producers completed and eight other tests, most of them wildcat ventures, were given up as dry holes.

Eugene Hilliard reported his A-5 State in Section 29 of Roscommon Township, Roscommon County, a wildcat, had come in for 50 bbl. a day natural from a depth of 4,963 ft. Sun Oil Co. 2 Wirth in Section 22, Osceola County, Osceola Township, produced 192 bbl. in 9 hours after acid treatment and in Aetna Township, Missaukee County, a Gordon Oil Co. test rated 65 bbl. with salt water cutting into its worth. Activities were scattered over 14 counties, the gassers being Taggart Brothers developments in Redding Township, Clare County.

State Conservation Department auction of lease rights on state-owned lands brought an average of 30 cents an acre on 20,970 acres made available for wildcat exploration. Highest bid was $8.25 an acre for a tract in Richfield Township, Roscommon County. Other better bids went for land in Ellsworth, Lake County; Beaverton, Gladwin County; Foster, in Ogemaw, and Garfield, in Bay. The sale put a total of 430,000 acres of state land under lease.

MICHIGAN COMPLETIONS

Allegan County, Ganges Township: Herb Calay 1 Sisson, NW NW SW 14-2n-16w, wildcat, dry, T.D. 1,268 ft.

Arenac County, Adams Township: Ervin Major 1 Hasty, NW SE 27-19n-3e, dry, T.D. 3,105 ft.

Calhoun County, Marengo Township: Ashby Drilling Co. 1 Paine, NW NW SW 12-2s-5w, wildcat, dry, T.D. 2,325 ft.

Clare County, Redding Township: Taggart Brothers Co. 3 Plesum-State, C NW 4-19n-6w, 2,020,000 cu. ft. gas, T.D. 1,308 ft.

Taggart Brothers Co. 4 Plesum, C NE Sec. 4, 2,120,000 cu. ft. gas, T.D. 1,315 ft.

Clinton County, Bath Township: American Drilling Co. 1 Redmond, N½ NE NE 20-5n-1w, wildcat, dry, T.D. 2,934 ft.

Crawford County, South Branch Township: Leo S. Schrot 1 Lintz, SE SE SE 3-25n-2w, wildcat, temporarily abandoned at 805 ft.

Leo S. Schrot 1 Lincoln, N½ NW SW 17-25n-1w, location abandoned.

Isabella County, Broomfield Township: L. & S. Drilling Co. 1 Leach, NW SE SE 7-14n-6w, temporarily abandoned at 1,290 ft.

Fremont Township: Union Drilling & Producing Co. 1 White-Curtiss, NE NE SE 5-13n-5w, wildcat test, dry, T.D. 3,705 ft.

Kent County, Cascade Township: Jetter & De Krafft 1 Merrill, SW SW NW 23-6n-10w, wildcat, dry, T.D. 2,430 ft.

Lake County, Saubie Township: Hubbell Oil Producing Co. 1 Myers estate, NE NW SW 16-10n-14w, dry, T.D. 2,156½ ft.

Missaukee County, Aetna Township: Gordon Oil Co. 1 Blue, S½ SE SE 26-22n-6w, 65 bbl. and salt water, acidized, T.D. 3,845 ft.

Osceola County, Osceola Township: Sun Oil Co. 2 Wirth, N½ SE SW 22-18n-8w, 192 bbl. first 9 hr., acidized, T.D. 3,781 ft.

Ottawa County, Zeeland Township: C. A. Perry-Cross & Gould 1 Nykamp et al, SE NW NE 31-5n-14w, pumping 10 bbl., T.D. 1,488 ft.

J. E. Hood 1 Moulder et al communitized, SE SE SE Sec. 30, pumping 17 bbl. and salt water, T.D. 1,505 ft.

Roscommon County, Roscommon Township: Eugene Hilliard A-5 State, N½ NE SW 29-21n-3w, wildcat, 50 bbl., natural, T.D. 4,963 ft.

Van Buren County, Bangor Township: Fisher-McCall Oil & Gas Co. and M. Bliss Keeler 1 Davis, SW SE NE 9-2s-16w, wildcat, pumping 60 bbl., natural, with salt water, T.D. 1,018 ft.

T. C. Hudson 6 Starz, SW NW NW Sec. 28, dry, T.D. 1,249 ft.

APPALACHIAN FIELDS

Chestnut Ridge Deep Test Reaches Onondaga Lime

PITTSBURGH, Pa. — On Chestnut Ridge in South Union Township, Fayette County, Greensboro Gas Co. cased to 7,317 ft. in lime in 2 Barton and apparently had reached the Onondaga lime, but after drilling was resumed the formation changed back to shale in which it is now drilling at 7,785 ft. In the 3 Barton, lime was topped at 7,606 ft. and the tools are at 7,610 ft. This hole was also cased in a lime formation at 6,828 ft. also believed Onondaga.

On Laurel Ridge in Ligonier Township, Westmoreland County, William E. Snee et al are drilling at 7,087 ft. in the test on the John and Eleanor Beck farm and so far have not placed any of the lower Devonian markers. In Maryland, William E. Snee et al has cleaned out old 1 Speicher on the Accident dome in Garrett County to 4,536 ft. and cemented at that point.

WEST VIRGINIA

In the activity in Raleigh County, Godfrey L. Cabot, Inc., completed a good gas well, 1054 Rockhouse Fork Land Co., in Trap Hill district with a gage of 4,998,000 cu. ft. of gas after shot. The total depth was 2,095 ft. with the Maxton sand topped at 1,950 ft. and gas from 1,979-2,018 ft. After a small shot, it gaged 1,043,000 cu. ft. and it was then shot with 20 qt. from 2,009-23 ft. and again with 20 qt. from 2,036-47 ft. after which it gaged nearly 5,000,000 ft. Rock pressure at the end of 24 hours was 421 lb.

In Wyoming County, the same operators completed a test on the C. C. Sharp farm, No. 1046, in Center district in the Big lime which after a bad fishing job now gaged 582,000 cu. ft. of gas before tubing. The Nos. 1070 and 1071 on this farm are now being rigged up.

WEST VIRGINIA COMPLETIONS

Boone County, Peytonia district: United Carbon Co. 5 Silver Coal & Land Co., 580,000 cu. ft. gas, Big lime top 1,325 ft., T.D. 1,494 ft.

Gilmer County, Glenville district: W. H. Mossor 1 Maggie Edwards, dry through Squaw sand, Big lime 2,000 ft., Big Injun 2,140 ft., T.D. 2,500 ft.

Kanawha County, Poca district: South Penn Natural Gas Co. 4 M. J. Wines, 3 bbl., Salt sand 1,120 ft., show gas 1,141 ft., oil 1,152-58 ft., shot 1,152-58 ft., T.D. 1,200 ft.

Union district: Shale Gas Co. 1 Wm. S. Pugh, 600,000 cu. ft. gas before shot, Big lime 1,657-1,797 ft., Injun 1,817 ft., gas 1,817-21 ft., T.D. 1,821 ft.

Marion County, Mannington district: South Penn Natural Gas Co. 9 W. N. Cunningham, 10 bbl. and 190,000 cu. ft. gas, Fourth sand, T.D. 3,256 ft.

Mingo County, Warfield district: Burning Creek M. & L. Co. 2 fee, 200,000 cu. ft. gas, Berea 2,260 ft., brown shale 2,640 ft., T.D. 3,108 ft.

Putnam County, Curry district: Summit Gas & Development Co. 1 F. M. and Reva Riddle, 45,000 cu. ft. gas, Big lime, T.D. 1,730 ft.

Ritchie County, Clay district: W. D. Gribble 3 Sadie McGinnis, 3 bbl., Maxton sand, T.D. 1,876 ft.

Pittsburgh & West Virginia Gas Co. 2 A. C. Barnard, 30,000 cu. ft. gas, Injun sand, T.D. 2,015 ft.

Upshur County, Meade district: Pittsburgh & West Virginia Gas Co. 7883 Eugene Hyre, 70,000 cu. ft. gas, Big lime 1,600 ft., gas from Benson sand, T.D. 4,267 ft.

Cumberland & Allegheny Gas Co. 328 W. W. Elmer, 52,000 cu. ft. gas, Big lime 1,535 ft., Injun 1,650 ft., R.P. 485 ft., gas from Injun and Riley sands, T.D. 4,175 ft.

Wirt County, Burning Springs district: Richter Oil Co. 14 M. Richter, drilled deeper, through Squaw sand, 34,000 cu. ft. gas, T.D. 1,964 ft.

W. C. Patterson 5 D. A. Riley, dry, Big lime 1,160 ft., Injun 1,314 ft., T.D. 1,368 ft.

ORISKANY GAS FIELDS

Jackson County, Ripley district: United Carbon Co. 1066 Elizabeth W. Perkins 10,116,000 cu. ft. gas, Oriskany 5,344-82 ft., shot 5,348-66 ft., R.P. 1,685 lb., T.D. 5,385 ft.

United Fuel Gas Co. 5122 J. B. Elliott, 3,810,000 cu. ft. gas before shot, 5,002-5,107 ft., Oriskany 5,107 ft., gas 5,111-20 ft., R.P. 1,670 lb., T.D. 5,124 ft.

Kanawha County, Poca district: Godfrey L. Cabot, Inc., 1064 Poca Coal Land Co. 4,500,000 cu. ft. gas, Oriskany 4,837 ft., shot 4,839-59 ft., T.D. 4,911 ft.

C-F
Weighted Illuminating
REGULATORS
Give Precise Control at Very LOW PRESSURES
The C-F regulator here illustrated may be used as reducing regulator, relief valve, or zero governor. It is designed for sensitive and sure operation governing the flow of low pressure gas to industrial burners, heat-treating furnaces, atmosphere controllers, inert gas generators, etc. Is an excellent district governor. Gives precise regulation of extremely low pressures at slight differential. Maximum inlet pressure 40 pounds, outlet range from atmosphere to 5 pounds. Sizes 1" to 2" screwed; 2" to 12" flanged. C-F Regulators cover all needs of pressure control as applied to gas, air, oil, water, steam. Write for more specific data.
THE CHAPLIN-FULTON MFG. CO.
38 PENN AVE.
PITTSBURGH, PA.

CANADIAN FIELDS

Experimental Proration Program Started

By VICTOR LAURISTON

CHATHAM, Ont.—Crude and natural-gasoline production from all Alberta fields for the week ending October 26 averaged 27,199 bbl. daily compared with 26,952 bbl. daily for the previous week and 27,398 bbl. daily for the corresponding week last year. The daily average included 26,065 bbl. of crude and 669 bbl. of natural gasoline from Turner Valley and 465 bbl. of crude from outside fields.

New Conservation Experiments

Individual orders have been issued by the Alberta Conservation Board relating to individual wells, or groups of wells, in Turner Valley. These orders replace the general order by which September allowables were continued in force throughout October. Under the new orders, some wells will continue under the Brown plan, with allotments on a basis of reservoir fluid per acre of drainage area; while other wells are operated experimentally under plans developed by the operators themselves, with allotments in barrels of oil each period of 24 hours or over varying periods up to 30 days. This experimental program was decided upon at a recent conference between the operators, the Conservation Board and Dr. G. Grainger Brown. By means of the experiment it is hoped to determine for each well, or group, the most efficient method of producing the largest output of crude consistent with the safety of the field.

Fort Norman Production

Official figures show that the crude production from the Fort Norman field in August totaled 9,077 bbl., compared with 7,945 bbl. in July and 2,524 bbl. in August 1941. Except for the production figures, no information is being given out regarding drilling operations which have been in progress since late in the spring, but the figures would indicate that a number of additional producers have been completed. While still comparatively small, the field is the largest individual producing area in Canada outside Turner Valley. It is probable that, pending transportation facilities, some of the completed wells have been shut in and that the output reported represents merely the crude that can be readily utilized under existing conditions.

Tar Sand Development

Plans to expand oil-recovering operations in the McMurray tar sand area of northern Alberta have been outlined by Max W. Ball, president of Abasand Oils, Ltd., which is now operating a small separation and re-

(Continued on Page 262)

ROCKY MOUNTAIN AREA

Horse Creek Discovery Starts Denver Basin Play

By T. R. INGRAM

DENVER, Colo. — A revival of wildcatting in the Denver basin (northeastern Colorado), which was forecasted with the General Petroleum discovery at Horse Creek, southeastern Wyoming, 2 weeks ago, got off to a start this week with the release of a location in the Buckingham district in Weld County. This is Ramsey Petroleum Corp. 1 Mabel R. Graham, C SW SW 14-7n-59w. Contract has been let to Manning & Martin, Inc., to go to 6,750 ft., which will provide a test of the Dakota series. Plans were formulated for this test, however, several months ago before the Horse Creek discovery took place.

The location of the Ramsey test is of particular interest. It is ⅛ mile southeast of the same company's 1 St. Anthony, drilled to the Dakota in 1932. This well had the Muddy sand at 6,680-6,700 ft. and gaged 6,000,000 cu. ft. of gas with a rock pressure of 1,800 lb. the first 24 hours. It was then deepened to 6,790 ft. It picked up the Dakota at 6,760 ft. and had 6 ft. of soft saturated sand. It swabbed 40 bbl. of oil the first 24 hours and 20 bbl. in the second period. It then drilled more sand at 6,768-74 ft. which proved to be wet, the water increasing to 20 bbl. an hour. Attempts to shut off bottom water were unsuccessful and the hole was plugged back to the Muddy and the well was completed as a gasser. After plugging back it showed for 4,000,000 cu. ft. of gas yielding 2½ gal. of distillates per 1,000 cu. ft. Two years later the well was abandoned. When the casing was pulled an attempt was made to shut off the water but the pressure was too strong. In a bailing test at this time the fluid consisted of approximately 25 per cent oil and 75 per cent water, both believed to be coming from the Dakota, which had been cemented off with only 8 sacks.

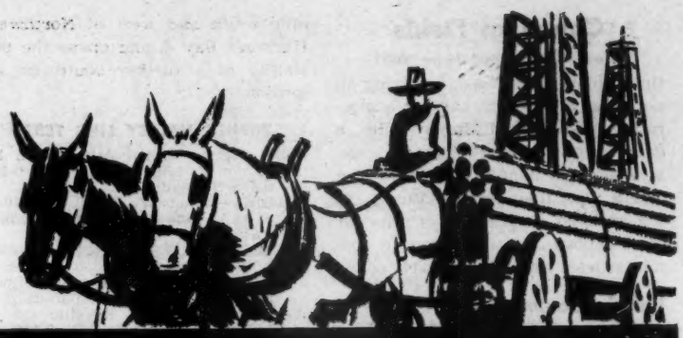
The indications were that the St. Anthony was an edge well and in 1933 Ramsey drilled 1 George Scriven ¾ mile to the southwest. It tested the Dakota at 6,891-94 ft. and had 3,000 ft. of water. The Muddy at 6,794-6,818 ft. was dry. The leases to the west of the St. Anthony well then were surrendered and those to the east were retained to permit drilling another well on that side. However, during the depression these also were surrendered, but a few months ago the area again was leased up.

The only other operation at present in that general area is the West Plains Oil Co. 1 Sheldon, SE NW SW 3-10n-55w, in Logan County, 30 miles to the northeast. It last was reported shut down at 3,660 ft. for casing. The test was drilled to this depth with cable tools and encountered all kinds of trouble from caving ground. Attempts now are being made to arrange for a rotary to complete it to the objective at 6,000 ft.

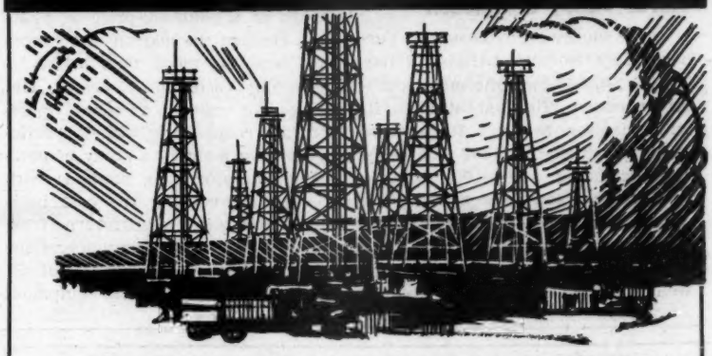
The General Petroleum discovery at Horse Creek, SW SE SE 31-17n-68w, Laramie County, Wyoming, on the northwest rim of the Denver basin, has not yet been tested on the pump. Rotary is being torn down and moved to the location for a second well ½ mile to the south. The latter will be drilled to the Sundance regardless of results in the Lakota, the productive horion in the first well. Two 500-bbl. tanks have been erected at the discovery for the pumping test and in the meantime oil is being trucked to the Frontier refinery at Cheyenne. The oil, which tests 30.4 gravity, congeals at 37° to 38° F. The record of the well is as follows: At the start the oil stood 5,230 ft. in the 2.7-in. tubing. It bailed 45 bbl. in 1½ hours and the column was lowered to 3,330 ft. It was then shut in for 1 hour and the column rose to 4,530 ft. On a swabbing test it was lowered to 4,280 ft. and again shut in for an hour. Then the column rose to 5,280 ft.

Ed Reagan 2 Tribal-194, C NW NE 27-37n-7w, northwest of the Cut Bank field in Montana near the Canadian border, a discovery in the Madison lime 2 months ago, swabbing 85 bbl. the first 24 hours with some bottom water, has succeeded in shutting off the water and is flowing 70 bbl. a

(Continued on Page 273)



FROM MULES TO MODERN POWER



BEGINNING at Petrolia back in 1908 with only a span of mules, our operations during the past thirty-four years have extended into California, Colorado, Oklahoma, Arkansas, Mississippi, Louisiana, and all of Texas. From Electra, Smackover, Mexia and Burkburnett to the present, our records show more than 2,000 oil and gas wells drilled under every condition. We have helped push derricks higher — and pipe lower, past 12,000-foot levels in the search for crude. We have used everything from the makeshift equipment of other days to our present modern rigs with gasoline, heavy steam, electric and diesel power. The experience we have gained is invaluable and the 250 men in our organization have a knowledge of drilling second to none in the business. We have come a long way in these thirty-four years and we're proud of our part in helping develop the industry. We look forward to new development with the same anticipation that we had in 1908.

HEAVY STEAM — DIESEL GASOLINE AND ELECTRIC

Al Buchanan

DRILLING CONTRACTOR

SAN ANTONIO, TEXAS

William M. Barret, Inc.

Consulting Geophysicists

Specializing in Magnetic Surveys

Contracts accepted for domestic and foreign projects, using the most improved instrumental and interpretative technique.

GIDDENS-LANE BUILDING -:- SHREVEPORT, LA.

Canadian Fields

(Continued from Page 260)

fining plant. The plans, involving an outlay of $12,000,000, call for a separation plant at McMurray with a daily output of 10,000 bbl. of crude, a refinery to handle this production and a pipe line from McMurray to the railhead at Waterways. The tar sand deposits are estimated to contain at least 100 billion barrels of oil.

Buffalo Coulee Tests

In the Buffalo Coulee area, between the Vermilion and Wainwright fields, Anglo Canadian-Home Oil 1, LSD 16, 26-47-7w4, finished in the lime around 3,310 ft., failed to develop commercial production, either in the lime or in the overlying Cretaceous zones, and has been abandoned. Anglo-Home 2 has been spotted in LSD 8, 35-47-7w4, and the outfit has been moved to the new location which is about a half mile due north of No. 1.

Turner Valley Completion

In the southwest extension of Turner Valley, Northwest-Hudson's Bay 8, LSD 2-3, 8-18-2w5, the most southerly producer, finished at 8,645 ft. with Madison at 8,214 ft., showed initial production of 557 bbl. daily after acidizing with 6,000 gallons. Production is being taken from both upper and lower porous zones of the Madison, at around 400 bbl. daily pending a definite allowable. This well extends the producing area ¼ mile south and west of Northwest-Hudson's Bay 6, and opens the possibility of a further southwest extension.

TURNER VALLEY LIME TESTS

North Turner Valley: Atlas-British Dominion 3, LSD 3, 17-21-3w5, below 8,310 ft., Madison 8,180 ft.

Northwest-Hudson's Bay 9, LSD 10, 8-21-3w5, below 8,068 ft., Madison 7,845 ft.

Home Oil 12, LSD 9, 5-21-3w5, below 8,785 ft., Madison 8,555 ft. Test is deep on structure but no water was indicated in the upper porous zone.

West-Central Section: Royalite Oil 65, LSD 16, 7-19-2w5, T.D. 7,143 ft., Madison 6,692 ft., acidizing and testing.

Vermilion Plant Closed

In the Vermilion field, eastern Alberta, the conditioning plant of Vermilion Consolidated Oils at Borrodaile has been shut down pending a study of the basic conditions under which it has been operating. The plant has been purchasing the Vermilion heavy crude at a field price of 90 cents per barrel, conditioning it for fuel oil and reselling to the C.N.R. at a contract price of $1.15. It is claimed the margin of 25 cents per barrel is more than offset by gathering costs of 15 cents and processing costs of 40 cents. Operators are cooperating with the refinery management in a study of gathering and processing methods with a view to reducing the cost basis and securing increased returns from the product. Processing operations have consisted in the removal of silt and water, but additional equipment may be provided to recover distillate and diesel fuel, estimated at 20 per cent of the Vermilion crude. The plant has been processing around 7,000 bbl. monthly, with a capacity of 300 bbl. daily, and represents the chief immediate market for the Vermilion production, though some crude is now being shipped to a refinery at Lloydminster. The Canadian National Railways have been purchasing the entire fuel-oil output of the Vermilion plant for use as locomotive fuel on its Rocky Mountain division, having given the plant earlier in the year a blanket order for 350,000 bbl. of the product. The C.N.R. has also been negotiating with leaseholders with a view to launching a new drilling program of 50 wells.

Operators and producers in the area have organized the Vermilion Oil and Gas Association for the purpose of investigating possible new markets, studying drilling and refining practices and securing a readjustment of field and refined prices. G. B. Webster, assistant oil controller for Canada, has been in Vermilion studying the situation in behalf of the federal government. Production is being continued, oil being pumped into storage pits.

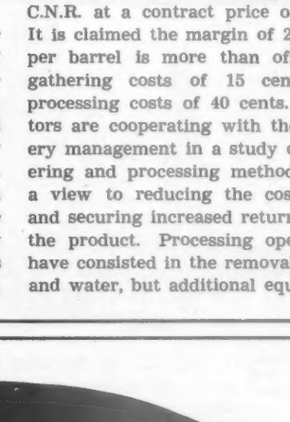
Border Fields

In the Taber field, southern Alberta, Standard of British Columbia 1, LSD 9, 19-9-16w4, is resuming production following completion of new installations at the Huff refinery at Lethbridge, which is handling the output. Standard 3 will be drilled offsetting the producer to the west, spudding to take place this month. Hi-Test 2, LSD 5, 22-9-16w4, has spudded and is below 212 ft. with surface casing set at 190 ft.

Lloydminster Oil Test

In western Saskatchewan, the Lloydminster gas field is to be tested for oil by Sasio Royalties of Saskatoon, which has location in LSD 8, 24-49-8w3. The company has extensive acreage on structure. A report by Prof. E. H. Edmunds of the University of Saskatchewan states that wells west and north of the location have struck either gas in commercial quantities or oil which indicated commercial production. East of the site, Colony 3 had good oil shows at 1,690 ft. and smaller shows at 1,905 ft. Production comes from lower Cretaceous beds encountered around 1,700 ft. and continuing for 550 ft. The most promising horizon is the Colony sand, near the top of the Cretaceous, but lower horizons have given shows of oil or gas. Preliminary tests of oil showings indicated a heavy black crude in commercial quantities. Preliminary bailing tests indicated flush productions from 100 to 248 bbl. in individual wells, but owing to lack of demand at the time for this type of crude, none of the wells has been tested by steady production.

GUARDIAN
of Vital PUMP PARTS



Twenty-four hours a day . . . seven days a week . . . regardless of weather or temperature, ABERCROMBIE SHEAR-RELIEF VALVES stay on the job to guard vital mud pump parts against damage from excessive pressures. Should pump pressures reach the shear stress of the nail in the valve, the nail shears and releases otherwise hazardous pressures. The operator merely resets the valve with another nail. His table of pressures and nail shear stresses are on the valve name-plate. So is the nail gauge so that he won't mistake nail sizes.

ABERCROMBIE PUMP CO.
GULF BLDG. HOUSTON, TEXAS

CURTIN CENTRIFUGES

Give you Quick, Accurate Results With *Less Effort* . . . . at *Less Cost*

Simple in design, ruggedly built for heavy duty service. Gear ratio and throw of crank produce required speed with no strain. Heads and cranks of 100 CC and 15 CC machines are interchangeable. **Meets A.S.T.M. Standard Method D-96 and A.P.I. Code No. 25 requirements.** Ask for full details.

W·H·CURTIN & CO. inc
HOUSTON U.S.A. TEXAS

Do you have
"DONE IN OIL" by Leven

Not too technical for the layman, this book has a wide appeal to every oil man . . . generously illustrated . . . authentically written. A book you should add to your library by all means.

1,084 Pages—Price $10.00

Book Dept., The Oil and Gas Journal

ABSTRACTS

of papers presented before the twenty-third annual meeting of the American Petroleum Institute, technical sessions, Chicago, November 9-13

AN ANALYSIS OF CERTAIN CIRCUITS IN CATHODIC PROTECTION. By Gordon N. Scott, Pipe-Line Technologist, Los Angeles, Calif.

IN seeking a solution to the troublesome problem of avoiding damage to pipe lines which lie adjacent to a cathodically protected pipe line, the author has found that a simple relationship exists between the concerned pipe lines in their ability to pass current through the wire bonding them together. This relationship resolves itself into a linear algebraic equation by which the external resistance of the circuit usually can be measured. This relationship has practical usefulness:

1. In designing a drainage bond, which is a wire connecting the two pipe lines, and controlling the amount of current passing between them.

2. In testing the efficiency of an insulated flange for current leakage to prevent consequent damage to the pipe.

3. In measuring the current density at which point the pipe becomes polarized to decide when sufficient cathodic protection has been applied to the structure to protect it.

4. In measuring the polarization as a test for the corrosivity of the soil.

Application of this principle of measurement, this algebraic equation, results in more useful information than ordinarily is obtained by an instrument designed for a particular measurement. For example, a potentiometer customarily is used to make a certain type of measurement on a pipe line. Applying the above-described relation, in conjunction with a multirange current-drawing instrument, not only gives the potentiometer reading, but also yields information on the resistance of the reference electrode used, as well as on the resistivity of the soil, and the total amount of current that can be drawn normally through a system. Understanding this relationship helps considerably to clarify the meaning of many other measurements which are daily made by workers in cathodic protection, and explains simply many problems and phenomena encountered in electrical protection of pipe lines.

●

SYNTHESIS AND PROPERTIES OF HYDROCARBONS OF HIGH MOLECULAR WEIGHT—2. By R. W. Schlesser, D. G. Clarke, C. S. Rowland, W. S. Sloatman and C. H. Herr, Pennsylvania State College, State College, Pa.; J. N. Cosby, General Aniline & Film Laboratories.

THE work during the past year of American Petroleum Institute Research Project 42 at the Pennsylvania State College on the synthesis and properties of hydrocarbons of high molecular weight is summarized in this paper.

Twenty new hydrocarbons in molecular weight from 336 to 434 have been prepared, making a total of 42 hydrocarbons of high molecular weight having a purity of 95 mole per cent, or better, that thus far have been reported by this project. The physical properties determined for each of the hydrocarbons are as follows:

1. Kinematic viscosity at 32°, 68°, 100°, 140°, and 210° F.; Saybolt Universal viscosity calculated for 100° and 210° F.

2. Kinematic viscosity index by the Dean and Davis method.

3. Density at 32°, 68°, 100°, 140°, and 210° F.; gravity, in degrees A.P.I., calculated.

4. Melting-point from the melting curve.

5. Boiling point at 0.50 mm. and 1.00 mm. from vapor-pressure curve over the range 0.50 mm. to 10.0 mm.

6. Heat of vaporization, calculated for the range 0.50 mm. to 10.0 mm. pressure.

7. Aniline point, reported in degrees Centigrade and degrees Fahrenheit.

8. Refractive index at 20°, 30°, and 40° C.

9. Specific and molecular refraction, calculated for 20° C.

10. Molecular volume, calculated for 20° C.

These data have been employed in checking the work of Kurtz and Lipkin on molecular volume, and the method for calculating refractive index of Lipkin and Martin. Several procedures for the estimation of the relative structure of hydrocarbon mixtures are examined. In addition, the work completed on three binary systems of the pure hydrocarbons is reported.

Tentative generalizations regarding the effect of chemical structure on physical properties have been drawn.

●

THE ENTHALPY OF GASEOUS HYDROCARBON MIXTURES. By B. H. Sage, R. H. Olds and W. N. Lacey, California Institute of Technology, Pasadena, Calif.

A METHOD for the prediction of the enthalpy (also known as heat content and total heat) of gaseous hydrocarbon mixtures is outlined. It uses the partial enthalpies of the components at the state in question. Preliminary values of these quantities are tabulated for the following: Methane in methane-ethane, methane-*n*-butane and *n*-pentane systems; ethane in the methane-ethane system; *n*-butane in the methane-*n*-butane system, and *n*-pentane in a methane-*n*-pentane system.

The degree of agreement between experimental and calculated values leaves much to be desired, but is still of engineering utility.

●

CORROSION PROTECTION OF STORAGE TANKS. By F. L. Newcomb, Standard Oil Development Co., Elizabeth, N. J.; E. S. Dixon, Humble Oil & Refining Co., Baytown, Tex., and C. F. Kelly, Texas Co., Port Arthur, Tex.

FOR a number of years extensive work has been carried on developing methods of corrosion protection for steel storage tanks. Galvanized roofs have shown a life double that of plain steel for less than double the cost. Galvanized tanks, in small sizes, have shown merit. Aluminum roofs have given good service, but are costly, particularly when aluminum rafters are used. Various coatings, including aluminum and lead foil, paints, enamels, synthetic resins, etc., generally have been unsatisfactory, although they afford some protection for a short period. Use of outside rafters on small tanks has resulted in reduced replacement costs. The use of spent caustic, when corrosion is due to aqueous solutions of hydrogen sulfide, has given good results. Electrolytic corrosion of tank bottoms has been controlled successfully by cathodic protection. Most of the foregoing methods of protection require the use of critical materials not available for such use.

Concrete has been employed for many years as protection for various parts of tanks. Successful methods of applying reinforced gunite linings are described and illustrated. These have been applied successfully when the tank was in such corroded condition that replacement was the only alternative. Costs per square foot are 40 cents for roof and structural members, 37½ cents for the shell, and 35 cents for the bottom—these totaling about half the cost of a new tank. The use of unreinforced gunite lining for protection of floating-roof tanks also is described.

Gunite protection of storage tanks appears to be the most feasible means of preventing corrosion and maintaining storage tanks for the duration of the emergency.

Guniting Tank Interiors

The Humble Oil & Refining Co. divides the guniting of the interior of a tank into three different steps: (1) Preparation of the surface; (2) installation of the reinforcement; and, (3) application of the gunite. All three steps are equally important.

In preparing the surface for gunite linings, the tanks first are steamed, cleaned, and made gas-free. After all dirt, oil, sludge, etc., has been removed, the metal surfaces to be gunited are sandblasted. The sandblasting operation is carried out with an operating air pressure of 100 lb. per sq. in., using a ⅜-in. sandblasting nozzle and graded silica sand. All surfaces are sandblasted until there is complete removal of all foreign material, including mill scale. This sandblasting operation not only assures a good bond between the steel and the gunite, but also serves to clean the steel surface, so that sound welds may be obtained where the reinforcing rods are tackwelded to the tank plates. The time required for placement of the reinforcement and guniting may be sufficient to permit the formation of some iron oxide on the sandblasted surfaces. As long as the iron oxide tightly adheres to the base metal, the discolorization of the base metal apparently does not affect the bond between the gunite and the steel.

The mix for the gunite lining consists of one part of cement to three parts by volume of sand. Clean, washed sand, with a nominal moisture content conforming to A.S.T.M. Specification C-33-39 for fine aggregates, is used. A standard brand of portland cement conforming to A.S.T.M. Specification C-150-40, Type I, is used. The cement and sand are mixed thoroughly, and then sifted on a ½-in. mesh screen. A Type N-1 cement gun is used for applying the gunite lining. It is applied to a 1-in. minimum thickness on the shell, roof, and structural members, and to a 2-in. minimum thickness on the bottom. When applied to thin roof sheets of old tanks, it may be necessary to apply the gunite in several coats, allowing the gunite to set up slightly between each coat to prevent excessive sagging and resultant cracking of the gunite.

The sequence of applying the gunite is from the tank top to the bottom. The under side of the roof, rafters, girders, and upper 5 ft. of the columns and shell are sandblasted. Reinforcing steel is installed, and the gunite applied. When the girder tops cannot be gunited, concrete is placed by hand. The ¼-in. vertical reinforcing bars for the shell need not be installed in 5-ft. lengths, but may be cut long enough to extend

from the tank top to the bottom. They can be tackwelded at the top of the shell, and left hanging loose until subsequent strips of lining are installed.

●

The Army's Internal Security Program

(Continued from Page 79)

An efficient, properly uniformed, highly trained properly supervised, and able-bodied guard force is of paramount importance. I will touch later upon the regulations that have been issued in connection with the plant guard militarization program.

Fencing and Floodlighting

Lastly, we come to the much discussed recommendations for fencing and floodlighting. Before the war we made recommendations to plants to install adequate fencing and to properly floodlight certain areas. Since December 7 the supply of materials for the chain-link type of fence has become so critical that we have been forced to issue instructions that only in cases of the most extreme necessity should such fences be installed, and only then around areas which could be best protected by this means. Several satisfactory substitute types of fencing which do not use any critical material have been developed and can be supplied in quantity to plants that must have this protection. Floodlighting is virtually out. The materials which are required in the manufacture of restricted types of fences and in all floodlights are so important to the armed forces that we are not forwarding for approval any requests except under most exceptional circumstances.

Plant Guards

I feel sure that you are interested in the militarization of plant guards. The guards that are employed in the plants in which you gentlemen are particularly interested are employes upon whom you place great responsibility. The purpose of the military organization is to increase the authority, efficiency, and responsibility of guard forces at plants vital to the war effort, and to provide auxiliary forces throughout the United States to supplement the Army in wartime emergency situations. The mission of a plant guard force is to provide internal and external protection of the plant against sabotage, espionage, and natural hazards. They are serving with the Army to provide protection for the plant and the area surrounding it against attack by enemy agents such as fifth columnists and parachute troops.

The War Department has assigned a commanding officer for each guard force, or for several guard forces where a number of smaller plants are located in an area. In addition to the commanding officer, an officer known as the plant guard officer, who will actually supervise the training of the guard with a staff of noncommissioned officers, has been assigned to each guard force.

Certain of the "articles of war" are read to the guards who will become members of the civilian auxiliary to military police. These articles define certain offenses as punishable by court martial of which persons subject to military law may be guilty, such as dereliction of duty, disorderly conduct, and commission of crimes; and deal with arrest, confinement, and other problems connected with military law. The guards who wish to join then execute an agreement. If a guard refuses to sign he may (but need not) be temporarily retained with the understanding that he will be dismissed as soon as a satisfactory substitute can be obtained. The officer in direct command of the guards will have custody of the agreements executed by the members of that guard force.

I will quote from paragraphs 10 and 11 of Circular 52, which establishes the regulations for plant guard forces:

"10. *Functional status.*—The guard forces will continue to function as formerly, except that a member of the Army of the United States will be in command at all times, and except that such forces will be trained and instructed with a view to supplementing the Army in resisting attack on war material, war premises, and war utilities which the force is assigned to guard. Control, therefore, will be exercised as heretofore through the plant management except at drill and except in emergency situations requiring the use of force against organized activities of fifth columnist or enemy paratroops.

"11. *Employe-employer relationship.* — The existing systems of hiring, compensation, and discharge are not changed. A court martial need not be convened to dismiss a guard. If the guard is employed by a private employer, the plant guard officer may recommend to the employer that the guard be dismissed, and, as heretofore, may even require his dismissal. If the guard is a War Department civil-service employe, the commanding officer can dismiss the guard without a court martial, and this dismissal can be effected in the same manner as in the past. Resignation from the force will be promptly approved by the plant guard officer, unless such resignation will seriously impair the efficiency of the guard force. A certificate of meritorious conduct, in the following form, will be issued to each guard honorably terminating service:

> "This is to certify that ..... has faithfully served as a civilian auxiliary to the military police at ....., during the Second World War, and his services are hereby honorably terminated.
>
> ....
> Date Plant Guard Officer

In the event of termination of service other than honorable, no such certificate will be issued."

A guard must be physically fit to perform his duties. It is left to the discretion of the plant guard officer to determine whether or not his physical fitness is satisfactory.

A guard force should be properly uniformed. A complete uniform is not required, although it is certainly preferred. Any one color of uniform is satisfactory. The War Department is providing arm bands which will be worn while guards are on duty. Badges are not required, but the company badges already in existence may be worn or companies may issue badges if they have not already done so. War Department certificates of membership will be issued to all members of the auxiliary military police. Each guard must carry at all times an identification card bearing his photograph, fingerprints, signature, and description, properly authenticated by the plant guard officer. No special form is required as long as it meets the above requirements.

If a plant guard officer recommends the arming of a guard force, it must be provided with appropriate weapons. Thorough training in the use of such weapons is obligatory. The plant guard officer should decide whether a guard is sufficiently trained in the use of his weapon before he is permitted to carry it.

A basic course of training for guard forces will be established. This course will require at least 1 hour a week for 20 weeks, and will cover the following subjects:

(*a*) Military courtesy and discipline, "articles of war."

(*b*) Defense against air and parachute attack.

(*c*) Interior and special guard duty (military only).

(*d*) Personal encounters.

(*e*) Inspections.

(*f*) Marksmanship—hand grenades, pistol, police riot club, shotgun, tommy gun (where applicable).

Advanced courses will be conducted for certain guard forces as follows:

(*a*) Riot formations.

(*b*) Approach marches.

(*c*) Other applicable subjects included in military-police tactical-unit training as provided in MTP 19-1, WD, May 6, 1942.

Over 100,000 guards have been enrolled to date in the auxiliary military police. We estimate that this is not quite 50 per cent of the men who will eventually sign the agreement. There will be difficulties of organization, and many technical and legal problems may arise. These will be settled as we come to them, and we ask your wholehearted cooperation in putting through the guard militarization plan.

I do not need to point out to you that the growth of the Army has been enormous over the last 3 years. We have suffered from some growing pains, but on the whole it has been remarkably free from serious difficulties. The spirit of cooperation and friendliness on the part of your industry is more than appreciated by those of us who have had the privilege of coming in contact with you. We hope that you will not hesitate to call on us if there are problems which we can assist you in solving.

●

Steps Taken to Keep More Tank Cars in Operation

WASHINGTON, D. C. — Following through on its announcement of preliminary steps to head off depletion of the supply of rail tank cars now being operated at a grinding pace to furnish oil to the East, the Office of Defense Transportation has announced formation of a committee to investigate maintenance and to make recommendations for a fuller utilization of these facilities.

Members of the committee include A. V. Bourque, chief of the Section of Tank Car Service of the ODT's Division of Petroleum and Other Liquid Transport; Boyd Wilson of OPC; W. C. Steffa and John S. Wood, both of New York, representing the owner shippers; J. J. Root, Jr., and J. S. Acworth, both of Chicago, representing lessors; and V. R. Hawthorne, Chicago, and W. E. Callahan, Washington, D. C., representing the American Association of Railroads.

The committee will meet in Washington soon to report to V. V. Boatner, director of the ODT Division of Railway Transport.

The investigating group will survey the physical condition of tank cars transporting petroleum into the East and determine the adequacy of repair facilities, considering the location of shops, class of repairs, supply of labor, availability of materials and other factors.

At the same time, ODT issued an appraisal of factors affecting the rail movement of petroleum to the East and an inventory of results since issuance of the general order affecting tank cars (No. 7).

Primary point made by the study was the expression of a doubt as to the ability of rails to increase the "high" of 850,000 bbl. per day. Many factors hamper the movement, among them the approaching winter weather, demands of other war essentials moving by tank car, and depletion of the car supply by reason of over-heavy duty.

Steps are being taken to cope with these problems, it was said.

New Target for Industry:

More Dollars Per Man Per Month in the PAY-ROLL WAR SAVINGS PLAN

TO WIN THIS WAR, more and more billions are needed and needed fast—AT LEAST A BILLION DOLLARS A MONTH IN WAR BOND SALES ALONE!

This means a *minimum* of 10 percent of the gross pay roll invested in War Bonds in every plant, office, firm, and factory in the land.

Best and quickest way to raise this money—and at the same time to "brake" inflation—is by stepping up the Pay-Roll War Savings Plan, having every company offer every worker the chance to buy MORE BONDS.

Truly, in this War of Survival, VICTORY BEGINS AT THE PAY WINDOW.

If your firm has already installed the Pay-Roll War Savings Plan, *now is the time—*

1. To secure wider employee participation.
2. *To encourage employees to increase the amount of their allotments for Bonds, to an average of at least 10 percent of earnings—because "token" payments will not win this war any more than "token" resistance will keep the enemy from our shores, our homes.*

If your firm has not already installed the Pay-Roll War Savings Plan, *now is the time to do so.* For full details, plus samples of result-getting literature and promotional helps, write, wire, or phone: War Savings Staff, Section E, Treasury Department, 709 Twelfth Street NW., Washington, D. C.

U. S. War Savings Bonds

This space is a contribution to America's all-out war program by

THE OIL AND GAS JOURNAL

The A.P.I. Converts to War Service

(Continued from Page 57)

cent of the amount that would have been necessary if two wells were drilled, according to a report presented by I. W. Alcorn, Pure Oil Co., and W. A. Alexander, of Shell Oil Co., Inc., both of Houston, Tex.

As drillers go ever deeper into the ground in the search for oil, the mud used in drilling becomes of extreme importance. Drilling mud, which is forced down through the drill pipe and then up outside the pipe, performs many functions, such as controlling the tremendous gas pressures that are often encountered, cleaning the drilling bit and carrying the drilled-out particles to the surface, plastering the side of the hole and others.

Because of these many functions, the mud must be compounded with high accuracy, and the compounding has become a chemical job, needing skilled chemical and mud engineers. A paper presented by Preston E. Chaney, of Sun Oil Co., Beaumont, Tex., described some of the mud problems that confront oil-well drillers, and offered methods of diagnosing the causes of trouble and correcting them.

Other papers included a description of various methods of predicting the shrinkage in the volume of oil because of the vaporization of the natural gas which is dissolved in the crude oil in the ground, by D. L. Katz, of University of Michigan, and a report of an investigation into the hydration-pressure relationships in clays and heaving shales, by H. H. Power, Barnaby L. Towle, and Joseph B. Plaza, of University of Texas. In drilling through underground formations of clay and heaving shale, drillers often encounter great difficulty because these formations expand into the drill hole, often stopping the drill and sometimes even exert sufficient pressure to crush the steel casing.

Dr. Cecil E. Boord, of Ohio State University, reported that 84 hydrocarbons and other products in the gasoline range have been synthesized and purified, tested in engines, and measured for their physical and thermal constants. The syntheses and purification were carried on at Ohio State, the engine testing by the research laboratories of General Motors and Ethyl Corp., and the measurement of constants by a selected group of chemists and physicists.

The total number of possible hydrocarbons runs into the millions, and most of them theoretically are in crude oil or could be synthesized from oil. Ordinary motor gasoline consists of a small group of these hydrocarbons that boil within a certain range. In the development of higher grade gasolines it was found that some of those hydrocarbons are much better fuels than the others, and this research project is especially designed to investigate the properties of all of the hydrocarbons in the gasoline range.

Other fundamental research into the hydrocarbon composition of petroleum has been carried on for many years in a number of projects, and two papers describing recent results in two of these sponsored by the Institute also were presented at today's session. Dr. Frederick D. Rossini of the National Bureau of Standards, who is director of one of the Institute projects, described a method used to analyze the gasoline fraction of petroleum. Coauthors of the paper are Beveridge J. Mair, Alphonse F. Forziati, Augustus R. Glasgow, Jr., and Charles B. Willingham, all of the National Bureau of Standards.

Synthesis and properties of hydrocarbons of high molecular weight, such as those which occur in lubricating oils, have been investigated for several years in another project carried on at the Pennsylvania State College. A paper describing work during the past year and reporting the preparation of 20 new hydrocarbons and the determination of their physical properties was presented; coauthors are R. W. Schiessler, J. N. Cosby, D. G. Clarke, C. S. Rowland, W. S. Sloatman, and C. H. Herr, all of the Pennsylvania State College.

Oxidation Methods for Chemical Production

(Continued from Page 73)

bon charge. A mixture of high-molecular-weight acids and esters, obtained as a residue from the oxidation vessel, amounted to about 38 per cent of the oxidation charge. This fraction has been found to contain dibasic acids, and, in fact, appreciable quantities of pure succinic acid ($C_2H_4(COOH)_2$) have been separated from this mixture of acids by ordinary physical means.

Commercial Oxidation of Natural Gas

The first successful commercial plant utilizing natural gas as a raw material for the production of chemicals by oxidation is believed to be that of the Cities Service Oil Co. at Tallant, Okla. At this plant large quantities of methanol and formaldehyde are being produced, along with smaller amounts of other chemicals, by the controlled oxidation of natural gas. It has been estimated that this and possibly some other similar plants were producing between one-fourth and one-third of the total supply of methanol and formaldehyde in the United States in 1941.[9]

The development of the oxidation process by Cities Service Oil Co. in the early part of 1928 was reported to have been the result of an investigation of a new treating procedure for natural gas designed to reduce pipe-line corrosion. The corrosion was believed to have been due to the presence of small amounts of oxygen in the natural gas and in order to eliminate this oxygen additional quantities of oxygen (air) were added to the gas subjected to pressure and high temperatures in order to initiate oxidation and thus remove all of the oxygen. The oxidation products were condensed from the treated gas and found to contain methanol, formaldehyde, acetaldehyde, and acetone.

The plant operations have been described briefly and a flow diagram for the operation appeared recently in the literature.[10] The operations are relatively simple and consist in compressing a mixture of natural gas and air and passing the mixture through a reaction zone at elevated temperatures. The reaction mixture is cooled on leaving the reactor and the liquid products are condensed and separated from the unoxidized gas. A portion of the gas stream from the separator is recycled, mixed with fresh feed and air, and further oxidized. The conditions of operation are not disclosed, and it is not known whether catalysts are used, but it is believed that the process is catalytic. It is stated that the temperature and pressures are low as compared with the temperatures and pressures required in many high-pressure syntheses. Presumably, equipment costs for such installations would not be excessive. In this connection it is believed that ordinary steel equipment is all that is required since the proportion of acids in the products is very low.

Methanol and formaldehyde are the main products of this plant and these compounds are produced in approximately equal proportions. In addition to these two compounds there is produced an appreciable quantity of acetaldehyde and smaller amounts of acetone. In separating the reaction products, an initial rough separation is made and these impure products are refractionated to produce the materials of commercial quality. Methanol and acetaldehyde are separated as pure compounds, formaldehyde is produced as a 40 per cent solution in water (formalin), and acetone, which is difficult to separate from mixtures containing methanol, is produced as so-called methyl acetone. This latter product is a mixture of methanol and acetone containing approximately 15 per cent of the former and is a valuable commercial solvent.

Market for Methanol and Formaldehyde

When Cities Service Oil Co. first started producing methanol and formaldehyde there was an abundant supply of both of these products. Methanol was being produced by a high-pressure catalytic process from carbon monoxide and hydrogen, and formaldehyde was being produced by the catalytic oxidation of methanol. Although at first the production of these two commodities from natural gas did not appear to be justified on the basis of market conditions there shortly arose a new large utilization for the formaldehyde, and indirectly the methanol: its use in the synthetic resin industry. This new and fast-growing industry was able to use all of the formaldehyde available.

Future Developments

The petroleum industry has seemingly been slow to realize and to capitalize upon the fact that their basic raw materials, crude oil and natural gas, can be profitably converted into chemical products. This reluctance to enter the chemical field can be traced to several fundamental factors:

1. The industry has been so engrossed in producing huge quantities of crude oil and refining this material at a profit that consideration of chemical outlets, which at best would utilize relatively small amounts of petroleum, has not seemed desirable.

2. The costs of plants required for chemical production are, in general, far greater than the usual refinery construction costs.

3. The rapidly changing character of the chemical market makes it imperative that a manufacturer be ready to convert his plants and processes to meet the changing conditions. Thus, chemicals that today are novelties and of little commercial value, may tomorrow be required in large quantities, and others, which today are being used in large amounts, may be displaced tomorrow by better or cheaper substitutes.

The petroleum chemical industry has a sound basic position because of its control of the cheapest source of hydrocarbon raw material and its future development will depend upon the ability of the personnel of this industry to improve upon present known methods and develop new methods for chemical processing.

References

[1]Padovani, C., and Franchetti, P., Giorn. chim. ind. applicata, 15, 429 (1933); Chem. Abs. 28, 2,853 (1934).
[2]Wiezevich, P. J., and Frolich, P. K., Ind. Eng. Chem., 26, 267 (1934).
[3]Burke, S. P., and Fryling, C. F., U.S.P. 1,991,344, Feb. 12, 1935; Chem. Abs., 29, 2,174 (1935).
[4]Paris, A. Chimie et industrie, 31, Spec. No. 411 (1934) Chem. Abs., 28, 5,806 (1934).
[5]Newitt, D. M., and Townend, D. T. A., J. Inst. Pet. Tech. 20, 252A (1934); Chem. Abs., 28, 4,871 (1934).
[6]Bludworth, J. E., U. S. P. 1,923,610, Aug. 22, 1933; Chem. Abs., 27, 5,341 (1933).
[7]Wheeler, T. S., and Blair, E. W., J. Soc. Chem. Ind., 42, 491 (1923).
[8]Unpublished data, obtained by Union Oil Co.
[9]Weiss, J. M., Chem. Ind., 49, 348 (1941).
[10]Chem. and Met. Engr., 49, No. 9, 154 (1942).

Houdry Process helps to make TIRES to get 'em up—GAS to keep 'em up!

The first stinging blow has been struck at Tokyo. It will be repeated again and again, and with growing force.

Thousands upon thousands of planes are being built for the task. Millions of men are being trained to fly and maintain them. And supporting this growing military might are America's men of science, working tirelessly to speed the day of retribution.

A tremendous part is being played by petroleum scientists. They have multiplied incredibly the production of 100-octane aviation gas. Most of the country's huge butadiene program for synthetic rubber is in their hands.

To both of these achievements the Houdry Catalytic Process has contributed notably. Millions of barrels of the finest aviation fuel in the world are now being produced in Houdry plants. In fact, without the principle of catalytic cracking which Houdry was the first to use commercially, America's war requirements for 100-octane gas could not have been met.

Houdry has met another, and totally different, war emergency. When Japan seized most of the world's natural rubber sources, the Houdry Process was ready to serve our vital need for synthetic rubber. A new and actually simplified application of it makes butadiene quickly and cheaply.

The advantages of the Houdry Process are positive and provable: it makes butadiene from either butane or butylene; higher yields are obtained at lower temperatures; plants can be built in minimum time and with minimum use of critical materials.

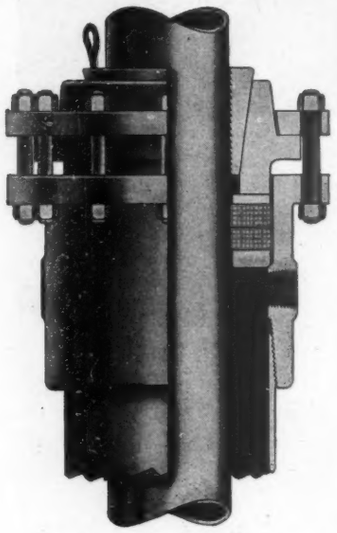
Synthetic rubber, from Houdry butadiene, soon may shoe the wheels of American airplanes—while their engines sing a song of vengeful power on Houdry 100-octane fighting fuel. We are proud to offer the Houdry Process to any and all American manufacturers without restriction, under license arrangements subject to approval by the United States Government.

HOUDRY PROCESS

THE HOUDRY PROCESS CORPORATION
WILMINGTON, DELAWARE

BREWSTER CASING HEADS

Any Size, Pressure or Combination



Refer to our Section in the COMPOSITE CATALOG

The BREWSTER CO., Inc.

Shreveport, Louisiana, U.S.A.

EXPORT:
Acme Well Supply Co., 19 Rector St., N. Y. C.

BUY WAR SAVINGS BONDS!

PIPE LINE REPAIR CLAMPS

Efficient—Economical More than 45,000 sold

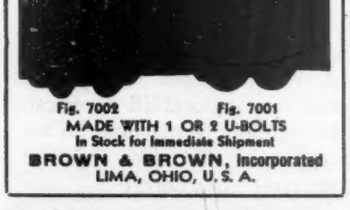
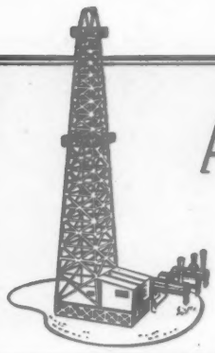


Fig. 7002 Fig. 7001

MADE WITH 1 OR 2 U-BOLTS
In Stock for Immediate Shipment

BROWN & BROWN, Incorporated
LIMA, OHIO, U. S. A.

If you haven't had that FREE list of important oil books, by all means send your request to the Book Department, The Oil and Gas Journal, Tulsa, Oklahoma



Among the Drilling

AMERICAN Drilling Co. has the contract to drill Talbot Oil Co. 2 Schwab, in C S½ SE NE 28-15n-4e, Bay County, Michigan.

LEWIS & ENGLE, of Bakersfield, Tex., have drilling contract on Cardinal Oil Co. 2-L White and Baker, new cperation 1,320 ft. north of Cardinal 1-L White and Baker, a new 175-bbl. wildcat producer located between the Walker and the White and Baker fields, Pecos County, Texas.

HELMERICH & PAYNE, Inc., are beginning work on two new wildcats for H. L. Hunt interests, Dallas, Tex. One is Hunt Oil Co. 1 McMillen and Turner, a 5,000-ft. cable-tool test in Sec. 5-26s-16e, Otero County, southeastern New Mexico. This test is on a 15,000-acre lease block which has been worked with surface geology by Fred S. Wright, of Midland, Tex., and which also has been aerially mapped by Edgar Tobin. The other test is Roy Lee, trustee, 1 J. A. Phillips in SW NE Section 15, Block 32, Township 3n, T.&P. Survey, on the east side of the West Texas Permian basin in Borden County, which will be a 4,200-ft. rotary wildcat test. In Kansas these contractors have started a test for Vickers Petroleum Co. as a south offset to the discovery well of the new Bean pool, McPherson County. Location is on the Hoffman lease, in 25-17-14w.

MUSKEGON Development Co. will drill Gulf Refining Co. 1 Fontaine, in C N½ SW NE 33-15n-4e, Bay County, Michigan. The company also has contract to drill Gulf's 1 Paige, in C N½ SW NW 34-15n-4e.

BUTLER & HORNE Drilling Co., Dallas, Tex., has made application to drill 2-A S. M. Reddin, a south offset to their 1-A Reddin. Location is 400 ft. from the south and 580 ft. from the east line of Section 4, J. A. Nabors Survey 9, Taylor County, Texas.

QUADRANGLE Drilling Co. has located for a test on the James O. Robertson tract, in Groton Township, Tompkins County, Pennsylvania, Oriskany gas area.

BALDRIDGE & KING, McAllen Tex., are moving in rig to drill a wildcat test (1 Gonzales) for Sun Oil Co. in Survey 370, 7 miles southeast of the Guerra field, northwestern Starr County, Texas. These contractors also are starting another test for themselves in the Santa Cruz grant, northwestern Hidalgo County. The latter test, 2 F. B. Guerra, is about 1,600 ft. east of Magnolia Petroleum Co.'s gas-distillate discovery in the South La Reforma area. It is expected to be drilled to 6,000 ft.

LUPHER Drilling Co. has been awarded contract to drill Rinehart & Hickok Highland Oil Corp. 6 AuSable, in SW SW SW 22-30n-3w, Otsego County, Michigan.

J. C. ARTHURS, Inc., will drill Virgil R. D. Kirkham 1 Albert Lindstrom, in C S½ SW NW 23-21n-9w, Wexford County, Michigan.

J. S. ABERCROMBIE Co., Houston, Tex., is running three rigs in Old Ocean field, Orange County, Texas. All the operations are for the account of the company itself, which is doing no drilling for other interests at this time.

HENRY SCHOOLER, of Big Lake, Tex., is drilling contractor on Floyd Scott and A. J. Rife 3 Thompson, short west outpost in the Noelke field, Crockett County, Texas. The well has set 8-in. casing at 756 ft.

NOBLE Drilling Co. was moving tools to the 1 Mayrhafen, in C NE SW 32-2n-23w, southwest of Duke, in Jackson County, Oklahoma. The contract is for 7,500 ft. or the Arbuckle on a farmout from Stanolind Oil & Gas Co.

ROWAN & HOPE Drilling Co., San Antonio, Tex., has the contract to drill the Frank Buttram 1 Cleveland, a wildcat northwest of the old White Point gas field, San Patricio County, Texas, which was starting last week. The same contractors are moving in rig for 1 Mrs. M. E. McCampbell, a 6,500-ft. test to be drilled for themselves in the Garcia grant, Victoria County. They are quitting 1 Southland, Santa Anita grant, northwestern Hidalgo County, as dry at 7,508 ft. and are moving off rig.

TRIANGLE Drilling Co., Shreveport, La., has spudded 3-B Murff, in 19-17n-11w, Sligo area, Bossier Parish, North Louisiana.

FALCON-SEABOARD Drilling Co., Tulsa, is rigging up for west offset to its discovery well of the new Lindborg South pool, McPherson County, Kansas. Location is 2 Beane estate, in 25-17s-4w.

Fred Manning, of MANNING & MARTIN, contractors of Denver; W. R. Ramsey, wildcatter of Oklahoma City, Okla.; and Clyde L. Wagner, of Tulsa, will launch an important wildcat test near the south end of the huge structure that embraces

Crew of H. & H. Drilling Co., Oklahoma City, Okla. The men are: H. R. Milsap, fireman; R. O. Webb, driller; C. S. Funkhauser, backup man; S. C. Hill, contractor; Roy Fickes, derrickman, and R. R. Cox, pipe racker

Contractors

parts of Wyoming, Nebraska, Colorado and a tip of northwestern Kansas, where the discovery of a rich high-gravity oil pool near Cheyenne, Wyo., and at the top of the Denver basin region, has revived interest in the territory east of the Rockies. The test is their 1 Sterling, in C SW SW 14-7n-59w, just south of Buckingham, Weld County, Colorado. Rotary tools will be used and it will seek production in the pay around 6,750 ft.

GEORGE P. LIVERMORE, Inc., Lubbock, Tex., is making good time on Helms 1 J. T. Harris, wildcat test in Section 103, Block M-10, B.S.&F. Survey, 19 miles northeast of Tulia, Swisher County, Texas. At latest report it was drilling below 4,370 ft.

ROY LEE, Dallas, Tex., is starting a wildcat test for Hunt Oil Co., 15 miles southwest of Gail, southwestern Borden County, Texas. The test, 1 Phillips, is scheduled to go to 4,200 ft. It will be drilled with rotary.

PORTABLE Drilling Co., drilling 1 R. V. Murray et al, C NW SE 34-13n-4e, west of Sparks, Lincoln County, Oklahoma, was drilling below 2,700 ft. Murray and associates plan another test soon in this county.

DUNCAN Drilling Co., Big Spring, Tex., has contracts to drill two scheduled wildcats in Scurry County, Texas. The tests will go to 4,000 ft. The contractor began moving in materials for the first test last week, the 1 Maxie Wilson, C SW NE 174-97-H.&T.C., 5 miles northeast of the Sharon Ridge pool and 6 miles southwest of Snyder. Upon its completion the 1 M. Stewart, C SW SW 211-97-H.&T.C., will be started. It will be 4 miles northwest of 1 Wilson and 6 miles due west of Snyder.

J. FRED POSTELLE, Odessa, Tex., is starting an 8,000-ft. contract test for Ohio Oil Co., on the J. T. Clark & Son lease, 9 miles west of Water Valley, southeastern Sterling County, Texas.

CREEKMORE-ROONEY Drilling Co. was fishing for lost tools at a depth of 1,550 ft. on the 1 Busby, in NW SW SE 11-4-5, near Bebee, in Pontotoc County, Oklahoma.

R. R. KIRCHNER, drilling contractor of Bristow, Okla., was running an 8⅛-in. casing at 2,774 ft. on the Herbert Gussman et al 1 Lamons estate, in SE NW SE 15-14-9e, in the Newby area of Creek County, Oklahoma. The test is being drilled with cable tools.

B. A. DUFFY, drilling contractor of Abilene, Tex., late last week spudded A. G. Talbot 1 W. J. Wilkinson, a scheduled Ordovician wildcat in northwest Menard County, Texas, C SE SE Section 55, John H. Gibson Survey.

CARRY & CARRY, of Graham and Breckenridge, Tex., have the contract to drill a 4,250-ft. wildcat test that has been spudded in and surface pipe set on the Sim Burgess land, 13 miles south of Graham. The contractors will use a rotary rig and will reach the Mississippian. The well is being drilled by A. G. Talbot Co., of which E. W. Robitaille, of Graham, is manager.

OLSON Drilling Co., Tulsa, has the contract for a 9,000-ft. wildcat test for Col-Tex Refining Co. on the latter's W. N. Reed lease, 15 miles northwest of Sterling City, Sterling County, Texas.

ROGERS BROTHERS Drilling Co. has spudded 1-A W. B. Grimes, L. Raney Survey, 6 miles east of Nocona, Montague County, Texas.

H. L. HUNT, Dallas, Tex., has been awarded a contract to drill a scheduled 6,000-ft. wildcat test for Shell Oil Co., Inc., on its 6,000-acre block in the Tennessee Colony area of northwest Anderson County, Texas, 10 miles southeast of the Cayuga pool. The wildcat, which will seek the Woodbine, will be the 1 Carroll & Welborn.

WALTER DROUGHT was awarded the contract to drill a well near the West Sunburst pool in Montana. Montana-Dakota Utilities Co. will drill the test 1½ miles southeast of the Parrent-Holbrook discovery well. Montana-Dakota is a large gas producer and is seeking to develop oil production. Location is SW 6-36-2w, Toole County.

GWYNN & OVERBY, Wichita Falls, Tex., is starting a joint test with Hanlon-Buchanan, Inc., on the Kinder lease, E. Pearce Survey, Jack County, Texas. Contract is for 6,400-ft. Rotary rig is being moved in.

HERNDON Drilling Co. 1 Suitor, a wildcat in SW SE NW 9-25-15w, south of Jacksville in Stafford County, Kansas, topped the Topeka lime at 3,170 ft., the Lansing lime at 3,818 ft., the conglomerate at 4,219 ft., and was making hole below 4,302 ft.

ALLIED Well Service, Inc., Houston, Tex., is engaged on a workover job for Gem Oil Co. in Polk County, Texas, about 15 miles east of Livingston.

CROWE Drilling Co., Hoisington, Kans., drilling Auto Ordnance Corp. et al 1-C Sandell, SW SE 5-17s-3w, in the northeast corner of the Lindsborg pool of McPherson County, Kansas, was below 3,300 ft. on last report. The company is using a portable rotary rig.

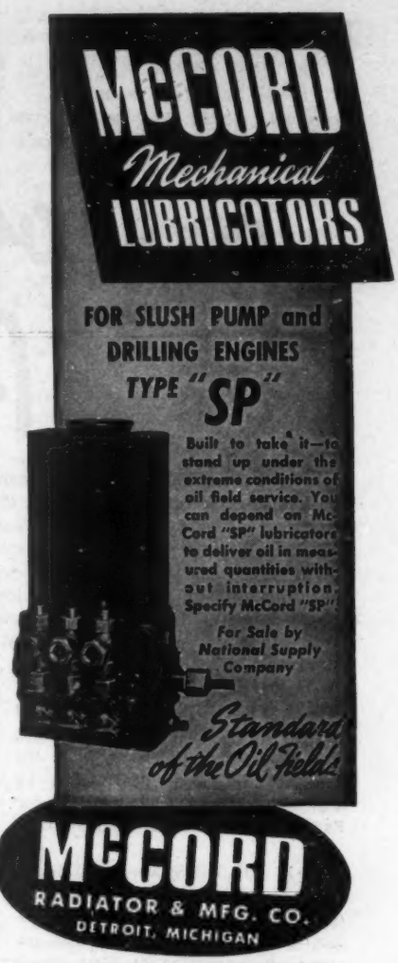
PRINCE BROTHERS, of Electra, Tex., have been given contract for J. B. Stoddard 1 W. E. Smith in the northeast corner of a 190-acre tract in the J. B. Edwards Survey, 1 mile west of Alma in Ellis County, East Texas district. The wildcat was reported to be located on a spread of 4,000 acres out of the Texas Co.'s 26,000-acre block. Contract depth was 6,500 ft., believed to be sufficiently deep to test the Smackover lime.

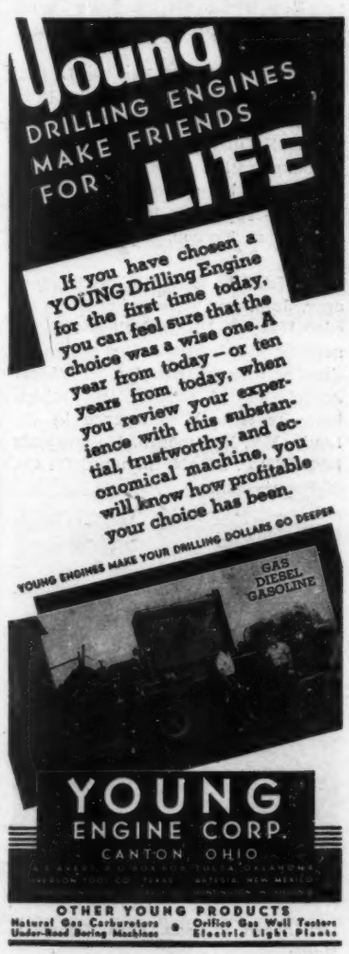
●

Appalachian Contractors Meet November 9

GENERAL MEETING of the Appalachian Drilling Contractors Association was scheduled to be held November 9, at Bradford, Pa. G. G. Bauer, executive secretary of the organization, was to report on the progress of the association and review briefly the activities which the association has undertaken during the past several months. The meeting was to consider also the dissemination of information on rationed tires and gasoline and other products in the form of an open forum with members of the local ration board on hand to answer any questions that might arise.

During the present trying situation, Mr. Bauer declared, it is necessary for every individual to keep as well informed as possible regarding the equipment available for use in his business. The drilling contracting industry is no exception. With transportation difficulties mounting as the result of tire and gasoline restrictions, it is important that every drilling contractor avail himself of every opportunity to secure proper information regarding this equipment.


McCORD
Mechanical
LUBRICATORS
FOR SLUSH PUMP and DRILLING ENGINES
TYPE "SP"
Built to take it—to stand up under the extreme conditions of oil field service. You can depend on McCord "SP" lubricators to deliver oil in measured quantities without interruption. Specify McCord "SP".
For Sale by National Supply Company
Standard of the Oil Fields
McCORD
RADIATOR & MFG. CO.
DETROIT, MICHIGAN


Young
DRILLING ENGINES MAKE FRIENDS FOR LIFE
If you have chosen a YOUNG Drilling Engine for the first time today, you can feel sure that the choice was a wise one. A year from today—or ten years from today, when you review your experience with this substantial, trustworthy, and economical machine, you will know how profitable your choice has been.
YOUNG ENGINES MAKE YOUR DRILLING DOLLARS GO DEEPER
GAS
DIESEL
GASOLINE
YOUNG
ENGINE CORP.
CANTON OHIO
OTHER YOUNG PRODUCTS
Natural Gas Carburetors • Orifice Gas Well Testers
Under-Reed Boring Machines • Electric Light Plants

Personal Paragraphs

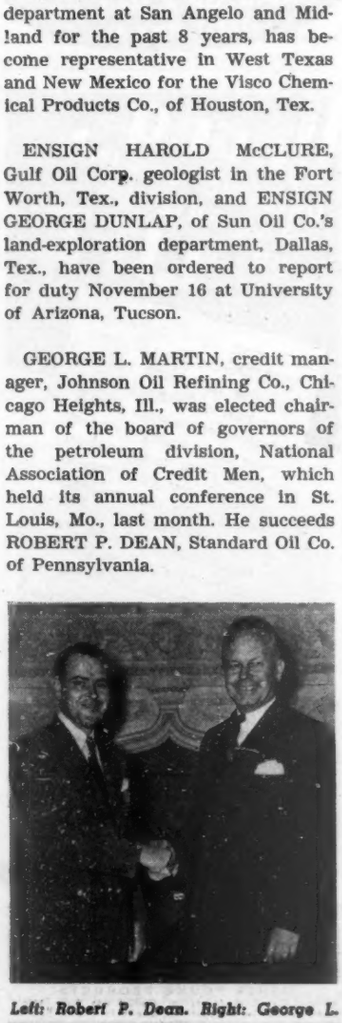
J. T. DICKERSON, who as general attorney and assistant secretary of Shell Oil Co., Inc., was in charge of legal work in the Texas Gulf area, has been granted a leave of absence. Commissioned a captain in the Army, he will serve in the directorate of intelligence service of the air forces. R. H. WHILDEN, formerly assistant manager of the area legal department, is acting manager.

L. J. VITTRUP, in the geological department of Texas Co. in Houston, Tex., for about 10 years, bade his associates goodby, announcing he was entering war service. He left for San Antonio, Tex., for induction.

J. E. DICKINSON, of Midland, Tex., a member of Sun Oil Co.'s land department at San Angelo and Midland for the past 8 years, has become representative in West Texas and New Mexico for the Visco Chemical Products Co., of Houston, Tex.

ENSIGN HAROLD McCLURE, Gulf Oil Corp. geologist in the Fort Worth, Tex., division, and ENSIGN GEORGE DUNLAP, of Sun Oil Co.'s land-exploration department, Dallas, Tex., have been ordered to report for duty November 16 at University of Arizona, Tucson.

GEORGE L. MARTIN, credit manager, Johnson Oil Refining Co., Chicago Heights, Ill., was elected chairman of the board of governors of the petroleum division, National Association of Credit Men, which held its annual conference in St. Louis, Mo., last month. He succeeds ROBERT P. DEAN, Standard Oil Co. of Pennsylvania.



Left: Robert P. Dean. Right: George L. Martin

SAM BUTLER, of Arab Gasoline Corp., Eastland, Tex., is assisting a brother-in-law, Phillip Sharples, head of Sharples Corp., of Philadelphia, Pa., in several drilling deals which the latter company is getting started in Texas and Louisiana fields. PAUL TORREY, consulting geologist of Houston, Tex., has handled the geological work for the company. JULIAN MEEKER, Fort Worth, Tex., independent operator, also has assisted the Sharples company on several new drilling deals in the coastal Louisiana area.

WILLIAM B. PLUMMER, manager of the development and patent department of Standard Oil Co. of Indiana, has been commissioned a lieutenant colonel in the U. S. Army for special duty in the office of the undersecretary of war. Mr. Plummer saw service as a second lieutenant in World War 1. He joined Standard of Indiana in 1930 as a chemical engineer.

DR. V. N. IPATIEFF, research chemist, and director of chemical research for Universal Oil Products Co., Chicago, Ill., and Mrs. Ipatieff, will be guests of honor at a banquet to be given by the Chicago chapter of the American Institute of Chemists, Friday, November 20, at the Adventurers Club, Chicago. The event will celebrate the seventy-fifth birthday anniversary of the scientist, the golden jubilee of his work in chemistry, and his and his wife's golden wedding anniversary. DR. VANDERVEER VOORHEES, standard Oil Co. of Indiana, will preside at the meeting, introduced by DR. GUSTAV EGLOFF, president of the A.I.C. and Universal's research director.

Do You Remember?

From The Oil and Gas Journal Files

40 YEARS AGO (1902)

President Stuart R. Knott, of the Kansas City Southern Railroad, visited Beaumont recently, and it is reported that he completed negotiations for the purchase of six oil wells on Spindletop. The road is burning fuel oil in its locomotives on the division from Shreveport, La., to Port Arthur, Tex.

It is reported that oil business in Rumania is on the decline, not because of failure of production, but for the reason that producers can find no market for their oil.

Prominent importers in the Argentine Republic are protesting against the granting of a monopoly for the sale of petroleum to Standard Oil Co., which the Argentine Republic is said to be contemplating.

25 YEARS AGO (1917)

Twenty-five tank cars have been purchased by Wilson Refining Co., Wilson, Okla. The company is to ship large quantities of its refined products to Pittsburgh, Pa.

Patriotic meetings were held last week at different towns in the Healdton oil field to arouse popular interest in national affairs and at the same time circumvent the activities of anti-Americans of the I.W.W. sort.

Russia's collapse as a war factor on the side of the Entente Allies, following the invasion of Italian soil by an immense German Army, had the effect last week of greatly depressing stock values in the oil industry.

10 YEARS AGO (1932)

Chief interest of oil men is again centered on the special session of the Texas Legislature which is considering a bill which would incorporate the market-demand provision designed to conserve the state's natural resources.

What is said to be the largest cracking chamber ever built arrived this week at the West Tulsa refinery of Mid-Continent Petroleum Corp. The still weighs 423,000 lb. It was mounted on two specially built flat cars.

Dr. Sidney Powers, for 13 years an official with Amerada Petroleum Co., died November 5 in a St. Louis, Mo., hospital following an operation.

CECIL HAGEN, independent geologist of Houston, Tex., is now a lieutenant, junior grade, in the Navy, on duty in Washington, D. C.

FRED P. SHAYES, of United Gas Co., Beeville, Tex., discussed "The History of Development of the Aqua Dulce Field," at the weekly meeting of the Houston Geological Society at the Texas State Hotel in Houston, Tex., last Thursday.

GEORGE R. LORD, general superintendent of refineries for Sinclair Refining Co., Inc., with offices in New York, was in Houston, Tex., several days in the past week, reviewing the status of the company's large construction program at the Houston plant.

H. L. HAAG, formerly assistant to J. W. SELBY, chief scout in the Houston, Tex., office of Shell Oil Co., Inc., has been transferred to Lake Charles, La., where he will be scout in the Southwest Louisiana district. He is succeeded in the Houston office by P. K. LANSDELL.

WALTER ABEL, for several years secretary-treasurer of the southern California section, A.I.M.E., recently resigned following acceptance of a position with the RFC in which he will be in charge of loans to mine operators and will consequently be out of his Los Angeles, Calif., office for extended periods.

FRANK L. WAGAR, manager of auto oil and grease sales at Tide Water Associated Oil Co., is helping to entertain thousands of service men. Known as one of the most competent magicians on the Pacific Coast, he has presented shows lately at Fort Funston, Fort Baker, Lettermen's Hospital, Hunter's Point, Camp Roberts, and many other Army and Navy headquarters. According to Mr. Wagar, his most enthusiastic audience were the invalids at Lettermen's Hospital.

THEODORE GLEN FISHER, production geologist for Cities Service Oil Co. in West Texas, has received a commission as lieutenant junior grade in the Navy, and is to report for duty November 16.

JACK S. SKELLY, chemist for Danciger Refineries, Inc., Fort Worth, Tex., addressed the Panhandle chapter, Division of Production of the A.P.I., at its second fall meeting in Pampa, Tex., last week.

O. D. DONNELL, president of Ohio Oil Co., Findlay, Ohio, was crowned a thirty-third degree Mason at the annual session of the Supreme Council of Scottish Rite Masons, Northern Masonic Jurisdiction, Boston, Mass., recently.

JACK DANCIGER, oil man of Fort Worth, Tex., associated with Danciger Oil & Refining Co., has been appointed honorary consul of Mexico in Fort Worth. He holds a similar office for the Dominican Republic.

WILLIAM ROSS and ROBERT KAHLE, of National Transit Co., Oil City, Pa., were honored by fellow workers on the eve of their departure for the Army last week. They were presented with purses of money.

JOHN H. BRINGHURST, chief engineer of American Republics Corp., Houston, Tex., has been elected president of the Texas section of the American Society of Civil Engineers, which closed its fall meeting in Houston last Friday.

B. R. WORTHY, production department pumper at Holdenville, Okla., for Mid-Continent Petroleum Corp., submitted a suggestion to the company for a "safety wheel" to be used for starting engines, which has been adopted, and is being considered for one of the high prizes in a company contest.

ARTHUR W. PAGE, director of Continental Oil Co., was elected chairman of the United Seamen's Service executive committee. Other oil executives on the board of trustees of United Seamen's Service include JOHN H. PEW, president, Sun Oil Co.; W. S. FARISH, president, Standard Oil Co. of New Jersey, and WILLIAM P. ROTH, treasurer, Honolulu Oil Corp.

THOMAS W. SIMMONS, president, Bolsa Chica Oil Corp., Los Angeles, Calif., is among 83 business and professional leaders who are attending a 4-week orientation course in Army organization and procedures at the General Staff School, Fort Leavenworth, Kansas. Invited by the War Department, the course is designed to provide information that will enable a selected group of civilians to understand more fully conditions under which the Army operates.

New Sohio Officials

Left: JOHN P. SMOOTS. Right: EARL D. WALLACE

Earl D. Wallace, newly appointed land and production manager in the crude oil production division of the supply and transportation department of Standard Oil Co. of Ohio, is a past president of the Kentucky Oil & Gas Association (1934-39), and is a member of the Petroleum Industry Production Committee for District 2, appointed by the Petroleum Coordinator for War.

Affiliated with Petroleum Exploration Co. from the time of his graduation from college until he recently resigned to accept a new post with Standard Oil, Mr. Wallace has been president of People's Gas Co. of Kentucky (a subsidiary) since 1932, and a director of Petroleum Exploration Co., Southern Petroleum Exploration Co. (another subsidiary operating in New Mexico and Texas), People's Gas and Wiser Oil Co. He has been a director of the Independent Petroleum Association of America for the past 3 years.

Mr. Wallace is a member of the Sigma Nu fraternity, was married in 1925 to Mary Frances Wilson of Lexington, Ky., and has two children, Earl, Jr., 14, and Betty, 16.

John P. Smoots, who has recently been named exploration and geological manager of the crude oil production division of the supply and transportation department of Standard Oil Co. of Ohio, is a native of Wadsworth, Ohio. He is a graduate of Logan, Ohio, public schools and Ohio State University where he received his degree in chemical engineering in 1915.

He joined the staff of the U. S. Bureau of Mines and served as a member of its petroleum research staff during 1917 and '18. During this war period he was assigned to cooperative fuel-research work with General Motors Corp. at Dayton.

From 1919 to 1924 he was a member of the geological staff of Arkansas Natural Gas Co., working largely in Louisiana and Oklahoma. In 1924 he was placed in charge of production and geological work for North Central Texas Oil Co. in Louisiana and Arkansas, continuing in this capacity until 1927.

He joined Standard Oil Co. of Ohio in 1928 and was first engaged in process development work but has been in charge of the company's production activities ever since it entered this field of operations.

Mr. Smoots was married to Miss Cleo Roquemore of Shreveport, La., in 1929 and they have two children, John, 12, and Robert, 8.

WOODROW WILSON and BUD WILLIAMS left Black Diamond, Alta., Canada, recently for Fort Norman, where they will drill for the Royalite Oil Co.

RAYMOND CARLILE has resigned as a deputy oil inspector of the Oklahoma Corporation Commission. He will be succeeded by HARRY PIERCE, of Boswell, Okla.

LOUIS E. ELLIS has been appointed Memphis (Tenn.) marketing division supervisor for Lion Oil Refining Co., El Dorado, Ark. He has been with the company since 1929.

ELLSWORTH M. CURRY, who has been a computer for Shell Oil Co., Inc., in the Bakersfield, Calif., office in the San Joaquin Valley division, has been advanced to assistant seismologist and will maintain offices in Bakersfield.

P. McDONALD BIDDISON, consulting engineer for Lone Star Gas Co. since 1931, has left for Washington, D. C., and a post with the War Production Board. He is a consultant in the power branch of the gas-supply section.

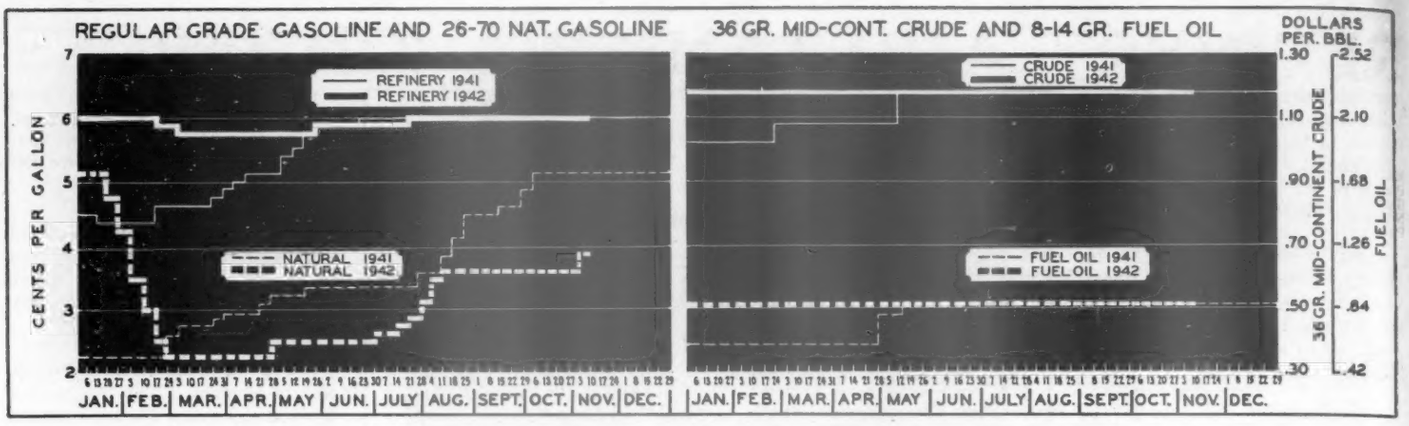
R. F. CUTTING has been appointed field representative for Herley & Kelley, California oil operators who maintain offices in Long Beach. These operators will start a new well in the Del Valle field within the next few days.

KENNETH E. BORN, associate geologist of the Tennessee Division of Geology, delivered an address before the Tulsa Geological Society Monday evening. His subject was "The Pre-Cretaceous Rocks in the Northern Part of the Mississippian Embayment."

RALPH T. ZOOK, president of Sloan & Zook Co., and A. C. SIMMONS, of Simmons Oil Corp. and president of the Bradford District Pennsylvania Oil Producers Association, were principal speakers at the annual dinner of the Bradford district research group last week.

R. G. GALEY, for the past 11 years superintendent of motor transportation throughout Canada for British-American Oil Co., Ltd., has been vested with responsibility for maintenance of motor equipment and transport over the 1,600 miles of the Alaska highway. He has been commissioned a lieutenant colonel by the Army.

ROBERT BRATTAIN, Shell Development Co., was in Los Angeles, Calif., last week in connection with a paper he presented to directors of the California Natural Gasoline Association on the Spectraphometer, which was developed by Shell Development Co. in connection with butane and other hydrocarbon mixture analysis.


REGULAR GRADE GASOLINE AND 26-70 NAT. GASOLINE
CENTS PER GALLON
REFINERY 1941
REFINERY 1942
NATURAL 1941
NATURAL 1942
JAN. FEB. MAR. APR. MAY JUN. JULY AUG. SEPT. OCT. NOV. DEC.
36 GR. MID-CONT. CRUDE AND 8-14 GR. FUEL OIL
DOLLARS PER BBL.
CRUDE 1941
CRUDE 1942
FUEL OIL 1941
FUEL OIL 1942
36 GR. MID-CONTINENT CRUDE
FUEL OIL
JAN. FEB. MAR. APR. MAY JUN. JULY AUG. SEPT. OCT. NOV. DEC.

MARKET DEVELOPMENTS . . .

East Coast

NEW YORK.—The fact that East Coast consumers still fail to appreciate the seriousness of the supply situation became apparent last week when the 4-day registration period was held. Despite the urgency of the situation, only 50 per cent of the consumers had registered in metropolitan New York in the first 3 days and 20 per cent were still unregistered at the end of the fourth day. The registration period was extended into this week to accommodate those who failed to meet the previously scheduled deadline.

The prospect of higher prices in the East Coast area as the result of increases in rail rates became less likely after Leon Henderson, OPA administrator, protested higher rates in an appearance before the Interstate Commerce Commission. Mr. Henderson pointed out that the greater costs incident to the use of the railroads were already costing the oil industry and East Coast consumers an estimated $300,000,000 annually. The proposed rate increase would add another $50,000,000 to this cost.

Joel Dean, OPA fuel rationing director, referred to the "alarming scarcity" of fuel oil in an address before trade association directors in New York and indicated that shipments by tanker were still declining. While no figures on tanker shipments are available they are reported to have been halved in the past 2 months. There are also reports that coastwise tanker operations will be suspended entirely after the first of the year. This possibility is heightened by the growing scope of the United Nations offensive that will require wider and larger distribution of oil products over the world.

Mid-Continent

BUYERS this week continued combing the Mid-Continent refinery market for major products. Inquiries circulating in the market were from potential customers in the northern and eastern states and, in many instances, represented business for the first quarter of 1943.

Tone of the market is firm. Prices are steady at currently quoted levels and a few products, particularly the fuel oils and natural gasoline, probably would move into higher price levels except for the uncertainties surrounding rationing, transportation and directives on the ratio of yields.

Refiners are unable to determine beyond a reasonable degree of accuracy what portion of the present demand is springing from the imminence of gasoline rationing. There is evidence at hand that most large distributors are anxious to enter the rationing cycle with inventories as strong as permitted by transportation limitations. Some traders fear that transportation limitations will become a more important factor in the winter. Evidence is already at hand that weather is slowing down tank-car speeds and the more severe service to which equipment has been subjected in recent months is taking an inevitable toll in available cars.

Inquiries are particularly strong for all grades of fuel oil, although the recent ceiling of 80 cents per barrel imposed on residual grades at Group 3 refineries has tended to soften prices throughout the market structure for affected products. Supplies are just as difficult to locate as before the OPA froze residual prices at 5 cents below the previous low of spot quotations.

SENTENCE SUMMARIES

MID-CONTINENT: Buyers continue active interest in virtually all products. Prices steady and unchanged.

GULF COAST: Lend-lease business absorbing large volumes of material. Stocks of distillate fuel rising for supplying "big inch" line.

EAST COAST: Supply position considered somewhat improved by recent arrivals of coastwise shipments.

PENNSYLVANIA: Market steady for all products. Lubricating oils in particularly brisk demand.

PACIFIC COAST: One substantial seller liberating quantities of gasoline on spot market at concession prices. Kerosene selling briskly for smudge oil.

A.P.I. REFINERY REPORT

Week Ended October 31, 1942

(Figures in thousands of barrels)

	Dly. crude runs to stills	Stocks: Gasoline	Residual	Gas oil
Appalachian	159	2,685	470	777
Ind., Ill., Ky.	764	13,752	2,940	6,325
Okla., Kans., Mo.	347	6,235	1,373	1,904
Censored area*	1,631	37,797	19,739	25,953
Rockies	103	1,643	570	424
California	727	17,047	54,488	12,947
Total Oct. 31, 1942	3,731	79,159	79,580	48,330
Total Oct. 24, 1942	3,776	79,545	79,073	47,567
Total Nov. 1, 1941	4,087	82,303	95,565	55,551

Note: Refinery runs and stocks for week ended November 7, 1942, appear on Trends page.

*Reports combined on East Coast, Texas Gulf, Louisiana-Arkansas and Inland Texas at request of OPC

CRUDE-OIL STOCKS

(Bureau of Mines Estimate)

Week ended:	Bbl. of crude*
October 31, 1942	239,266,000
October 24, 1942	237,986,000
November 1, 1941	243,340,000

*Excludes heavy, unrefinable crude in California.

Gulf Coast

HOUSTON, Tex.—A firm spot market for all refinery products was reported this week in the Gulf Coast district. Though trading was not brisk, demand was preventing accumulation of material that might prove a problem. Gasoline stocks, which ordinarily have begun their seasonal rise by this time, were gradually declining in the Gulf Coast area. This reversal of the usual market form was attributed largely to lease-lend buying.

Refiners said stocks of gas oil were growing, but they expressed little or no concern. Not only are large naval and lend-lease purchases reported, but when the "big inch" line begins operation next month these accumulations are expected to shrink. The "big inch" line will require 100,000 to 120,000 bbl. daily of distillate fuel under present operating plans.

Service stations will be hard hit by the forthcoming gasoline rationing, just as they have been in the East, where the plan has been in operation since last May. An opinion expressed by refiners here is that retailers whose regular business in the past has not exceeded 8,000 gal. a month will be forced to close after nation-wide rationing becomes effective.

Pacific Coast

LOS ANGELES, Calif.—Demand for gasoline is off slightly but increases may be expected before gasoline rationing goes into effect on November 22. Gasoline prices are unchanged and moving only in limited quantities at low prices. One fairly large marketer is setting the market pace with low prices on a volume basis, thus preventing other suppliers from raising prices to pegged maximum.

Fuel oil demand dropped off slightly in September but this is probably due to temporary decreased liftings by the military forces.

Gas oil is in good demand and there is a market for every barrel produced as large marketers are willing to buy all offered. Gas oil and light distillates are being used as blending stock with heavy fuel oil to meet Navy specifications.

Natural gasoline production has been fairly stable and current production is moving for the most part on contract basis leaving very little or none in the spot market.

Kerosene stocks are being built up to take care of smudging oil requirements. Use of old automobile tires to build up a smoke screen during cold periods has been stopped and from now on growers will be obliged to use oil, gas or coal.

REFINERY AND TANK-WAGON PRICES

(Prices as of November 10)

Quotations are f.o.b. plant in cars and in cents per gallon except where otherwise noted. They are exclusive of the federal excise taxes of 1.5 cents a gallon on gasoline and 4.5 cents a gallon lubricating oils, and do not include marine lighterage charges.

Refinery Gasoline

Octane (A.S.T.M.):	†80	78	74-76	72-74	68-70	63-66	60 & lower
Mid-Continent*	.....	.....	.....	5.875-6.000	.....	5.500-5.625	5.125-5.250
Pennsylvania	.....	.....	6.750-7.000	.....	.....	.....	.....
Gulf Coast‡	6.00-6.50	.....	.....	§5.750-6.250	§5.750-6.250	§5.250-5.750	§5.000-5.500
Northeast Coast	9.80	.....	.....	9.2	9.2	.....	.....
Pacific Coast	.....	6.500-7.000	6.250-6.500	6.125-6.250	5.750-6.000	5.125-5.250	4.750-5.000

*Basis Group 3. †1939 C.F.R. (research method). ‡Integrated companies restricted to lowest prices. §Unleaded.

Natural Gasoline

Grades:	26-70	18-55	75-85(350-375)
Oklahoma (Group 3)	3.875	4.650	.....
North Texas	3.500	4.200	.....
North Louisiana	3.625	4.350	.....
California	.....	.....	4.875-5.500

Kerosene and No. 1 Fuel Oil

Gravity:	46	45	42-44	41-43	38-40
Mid-Continent*	.....	.....	4.500	4.375	.....
North Louisiana	.....	.....	.....	4.500-4.750	.....
Pennsylvania	6.250-6.625	6.125-6.250	.....	.....	.....
California	.....	.....	.....	4.500-5.500	4.250
Northeast Coast	.....	.....	.....	6.80	.....
Gulf Coast	.....	.....	.....	3.875	.....

*Basis Oklahoma Group 3.

Tractor, Diesel, and Bunker Fuel Oil

Specifications:	46-48° G.	24 D.I.	48-52 D.I.	58 & above	Diesel bunkers	Bunker C
Mid-Continent*	4.125	.....	.....	.....	.....	.....
California	.....	2.750-4.000	.....	.....	‡$1.35-1.45	$0.85-0.90
Gulf Coast	.....	.....	4.000	4.125	1.45	0.85
Northeast Coast	.....	.....	.....	6.800	2.780	1.65
North Louisiana	.....	.....	.....	.....	.....	†0.80-0.85

*Basis Oklahoma Group 3. †10-14° gravity. ‡Pacific Specification 200.

Furnace Oil, Gas Oil, Fuel Oil

	No. 2	No. 3	No. 5	No. 6
Mid-Continent*	3.625-3.750	3.500-3.625	$0.85	$0.80
Pennsylvania (West)	5.875-6.125	5.875-6.000	†5.250-5.500	.....
Northeast Coast	6.7	6.7	1.95	1.65
Pacific Coast	5.5	5.5	‡0.80-95	§0.80
Gulf Coast	3.875-40	.....	1.65	0.85

*Basis Oklahoma Group 3. †36-40 gravity fuel oil. ‡Pacific Specification 300. §Pacific Specification 400.

Lubricating Oils

Bright and Steam Refined

OKLAHOMA (Group 3)—		
280-210 D, 10-25		27.00
150-160 D, 0-10		23.00
120-125 D, 0-10		22.00
Steam refined:		
600 dark green (untreated)	9.00	9.50
PENNSYLVANIA—		
Bright Stocks (Pennsylvania Grade No. 8 color, 140-150 at 210, 545-550 flash):		
10 pour point		30.50
15 pour point		29.50
25 pour point	25.00	28.00
Steam refined:		
600	15.00	16.00
650	15.50	16.50
600 flash	16.00	17.50
680 flash	17.00	17.50

Neutral Oil

(Vis. at 100° F. except Pennsylvania and color N.G.A.)

OKLAHOMA (Group 3)—	
0-10 pour point:	
200-3	15.00
300-3	18.00
500-3	19.50
600-3	20.00

Note: Viscous neutrals, 10-25 pour, quoted 0.5 cent under 0-10 oils.

Wax

(Cents per pound)

OKLAHOMA (Group 3)—	
124-126 (A.m.p.) w.c. scale	4.250
PENNSYLVANIA (inland refineries)—	
122-124 (A.m.p.) w.c. scale	4.250
124-126 (A.m.p.) w.c. scale	4.250

Neutral Oil

CALIFORNIA—		
Pale oils:		
200-2½-3	7.00	7.75
400-3-4	7.25	8.00
600-3-4	8.75	11.00
Red oils:		
200-4-5	7.00	7.75
400-5-6	9.00	11.00
500-900, 5-6½	9.25	11.25
GULF COAST—		
Pale oils:		
200-3	8.50	8.75
300-3	9.00	9.25
500-3½	9.75	10.00
750-3½	10.00	10.25
2,000-4	10.50	10.75
3,000-4	12.25	12.50
PENNSYLVANIA—		
150 vis. at 70° F., 3 color, 400-405 flash:		
Zero pour point		37.50
10 pour point		36.50
15 pour point		35.50
25 pour point		30.00
200 vis. at 70° F., 3 color:		
Zero pour point		39.50
10 pour point		38.50
15 pour point		37.50
25 pour point		32.00
NEW YORK—		
Wax in bags fully refined:		
130-132 (A.m.p.) wax		5.850
133-135 (A.m.p.) wax		6.150
Crude scale:		
124-126 (A.m.p.) w.s.		4.250
124-126 (A.m.p.) y.s.		4.250

EXPORT PRICES

Gasoline—60-62° Gravity, Maximum 400 End Point

Octane:	72-74	68-70	65-66	60
Gulf Coast	6.050	6.250-6.500	5.875	5.625
Pacific Coast	.....	6.125-6.500	5.875-6.000	5.500-5.625

Distillate and Fuel Oil

	Kerosene	Diesel fuel			Bunker
	41-43	24 G.	48-52 D.I.	58 D.I. Bunkers	C grade
Gulf Coast	4.000-4.250	.....	4.125-4.375	4.375 $1.65-80	$0.85-95
Pacific Coast	4.750-5.000	1.25-30	.....	..... †1.35-45	*0.80-90

*Pacific Specification 400. †Pacific Specification 200.

Lubricating Oils

	Neutral oils		Bright and cylinder stocks		
	200-3	150-3	200-3	150-3	600&680 S.R.
Mid-Continent	16.8	.....	28.8	24.8	.....
Pennsylvania	43-50	41-46	36-37	36-37	26.5-27

GASOLINE AND KEROSENE TANK-WAGON PRICES IN 50 CITIES

(Gasoline prices based on regular grades, tax included, undivided dealer)

ATLANTIC AND NEW ENGLAND

(Socony-Vacuum Oil Co., Inc., and Atlantic Refining Co.)

	Dealer tank wagon	Combined tax	Kero. tank wag.
Baltimore, Md.	15.45	5.50	10.20
Boston, Mass.	14.90	4.50	9.50
Burlington, Vt.	16.90	5.50	.....
Buffalo, N. Y.	16.20	5.50	10.30
Dover, Del.	16.70	5.50	11.20
Hartford, Conn.	15.60	4.50	.....
Manchester, N. H.	17.30	5.50	10.50
Newark, N. J.	14.70	4.50	9.40
New York, N. Y.	16.10	5.50	9.50
Philadelphia, Pa.	16.20	5.50	11.65
Pittsburgh, Pa.	16.70	5.50	12.00
Portland, Me.	16.30	5.50	9.60
Providence, R. I.	15.00	4.50	9.30
Washington, D. C.	14.70	3.50	10.70
Average 14 cities	15.91	5.07	10.32

(All prices undivided dealer basis.)

CENTRAL

(Standard Oil Co. of Indiana, Standard Oil Co. of Ohio, Continental Oil Co. and Texas Co.)

	Dealer tank wagon	Combined tax	Kero. tank wag.
Chicago, Ill.	13.40	4.50	10.30
Cleveland, Ohio	15.00	5.50	*9.00
Dallas, Tex.	13.00	5.50	7.00
Des Moines, Iowa	14.40	4.50	9.80
Detroit, Mich.	14.40	4.50	9.60
Fargo, N. D.	16.90	5.50	11.30
Huron, S. D.	16.30	5.50	10.70
Indianapolis, Ind.	15.20	5.50	9.80
Little Rock, Ark.	17.50	8.00	10.00
Milwaukee, Wis.	16.10	5.50	10.50
Minneapolis, Minn.	15.40	5.50	10.30
Omaha, Neb.	15.40	6.50	9.80
Tulsa, Okla.	16.50	7.00	8.50
Wichita, Kans.	12.70	4.50	8.00
Average 14 cities	15.15	5.57	9.61

*Includes 1-cent state tax.

SOUTHEASTERN

(Standard Oil Companies of New Jersey, Kentucky, and Louisiana)

	Dealer tank wagon	Combined tax	Kero. tank wag.
Atlanta, Ga.	21.40	7.50	11.40
Birmingham, Ala.	18.50	8.50	9.00
Charleston, S. C.	18.45	7.50	.....
Charleston, W. Va.	18.75	7.50	13.00
Charlotte, N. C.	19.60	7.50	11.00
Jacksonville, Fla.	21.40	8.50	10.40
Jackson, Miss.	17.50	7.50	8.50
Louisville, Ky.	16.50	6.50	8.50
Memphis, Tenn.	18.60	8.50	10.50
New Orleans, La.	16.75	8.50	*10.00
Norfolk, Va.	16.95	6.50	13.50
Average 11 cities	18.58	7.59	10.58

*Includes 1-cent state tax.

MIDWESTERN

(Continental Oil Co.)

	Dealer tank wagon	Combined tax	Kero. tank wag.
Albuquerque, N. M.	17.50	7.50	10.00
Boise, Idaho	20.10	6.50	16.50
Casper, Wyo.	17.00	5.50	12.00
Denver, Colo.	14.50	5.50	11.00
Helena, Mont.	17.00	6.50	13.00
Phoenix, Ariz.	18.50	6.50	12.50
Reno, Nev.	17.50	5.50	13.50
Salt Lake, Utah	18.50	6.50	14.50
Average 8 cities	17.58	6.25	12.88

PACIFIC COAST

(Standard Oil Co. of California)

	Dealer tank wagon	Combined tax	Kero. tank wag.
Portland, Ore.	17.00	6.50	13.50
San Francisco, Calif.	14.50	4.50	11.50
Seattle, Wash.	17.00	6.50	13.50
Average 3 cities	16.17	5.83	12.83
Average 50 cities	16.57	5.96	10.76
Average last week	16.57	5.96	10.76

Rocky Mountain Area

(Continued from Page 261)

day through the tubing. The operator is going back into 1 Tribal, ½ mile to the north, and will deeepen it to the producing horizon found in the second well. The first well, which was a gas discovery in 1941, made 6,000,000 cu. ft. of gas from the top of the Madison. It stopped 45 ft. in the lime while the second well had the oil at 64 to 68 ft. below the top.

The Broderick & Gordon 1 Fidelity Trust, south of the Tensleep oil wells at Pilot Butte, which showed for 35,000,000 cu. ft. of gas, estimated, in the Muddy sand on a drillstem test, is drilling ahead at 3,565 ft. toward the Tensleep.

Montana crude production in September, as reported by the state Oil Conservation Board, was 677,217 bbl. from all fields, an increase of 31,627 bbl. over the same month last year and a decrease of 14,076 as compared to August. Demand was in excess of production and 293,912 bbl. were withdrawn from storage in September. Exports to Canada were 204,172 bbl. in September, compared to 23,722 bbl. in the same month last year, an increase of 219,650 bbl.

WYOMING COMPLETIONS

Cole Creek, Natrona County: General Petroleum Corp. 77-16-S, NW SE SE 16-35n-77w, T.D. 4,585 ft., 5½-in. on bottom and perf. opposite Shannon sand, pumped 65 bbl. per day.

Wert field, Carbon-Sweetwater counties: Sinclair-Wyoming Oil Co. 29 Wertz, SE NE SE 1-26n-90w, T.D. 6,332 ft., 7-in. cemented on top Tensleep at 6,020 ft., pumped 480 bbl. per day.

CRUDE-OIL PRICES

Representative selected crude prices from all sections of the country appear below:

East Texas	$1.25
Conroe	1.43
Tepetate, Louisiana	1.18
Illinois basin	1.37
Pecos County, Texas	.95
Bradford, Pennsylvania	3.00
Van, Van Zandt County, Texas*	1.08

*No change since 5-21-41.

Gravity Schedules

Top prices include all gravities above grades designated, and low prices include all gravities below grades designated:

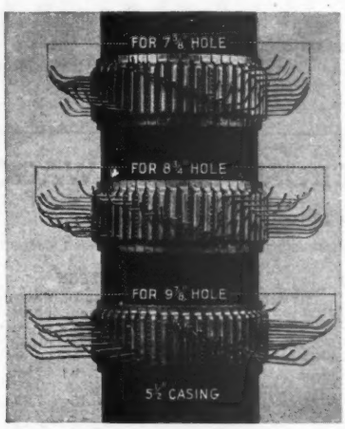
Gravity	Signal Hill, Calif.	Oklahoma, Kansas	Gulf Coast Texas	West Texas*
18-18.9	$0.80	.....	.....	.....
19-19.9	.84	.....	$1.00	$0.70
20-20.9	.88	$0.35	1.08	.72
21-21.9	.92	.87	1.10	.74
22-22.9	.96	.89	1.12	.76
23-23.9	1.00	.91	1.14	.78
24-24.9	1.03	.93	1.16	.80
25-25.9	1.07	.95	1.18	.82
26-26.9	1.11	.97	1.20	.84
27-27.9	1.15	.99	1.22	.86
28-28.9	1.18	1.01	1.24	.88
29-29.9	1.20	1.03	1.26	.90
30-30.9	1.23	1.05	1.28	.92
31-31.9	....	1.07	1.30	.94
32-32.9	....	1.09	1.32	.96
33-33.9	....	1.11	1.34	.98
34-34.9	....	1.13	1.36	1.00
35-35.9	....	1.15	1.38	1.02
36-36.9	....	1.17	1.40	1.04
37-37.9	....	1.19	1.42	1.06
38-38.9	....	1.21	1.44	1.08
39-39.9	....	1.23	1.46	1.10
40 and above	....	1.25	1.48	1.12

*Includes Lea County, New Mexico.

EQUIPMENT PROGRESS...

New Cementing Guides for Various Clearances

Wall-cleaning guides are now furnished by B and W, Inc., Long Beach, Calif., for various clearances between the casing and wall of the hole. Short, standard and long wire lengths now are available for such combinations as 5½-in. casing in 7⅞, 8¾ or 9⅞-in.



hole. The outer wire diameter usually is 1½ to 2-in. greater than the hole diameter, to provide centering by the torque spring action of the steel wires, and mud removal by scratching the face of the formation. Special wire lengths also are available for mud removal during open-hole plugging or gravel-packing operations.

New A-C All-Position Welding Electrode

A new electrode designed specifically for all-position welding of mild steel with a.c. type welding machines has been developed by Air Reduction Sales Co., 60 East Forty-second Street, New York City, in the following diameters: ⅛ to 5/32 in. Made to fill a rapidly growing need for a high-quality a.c. electrode for all-position use the Airco No. 230 electrode complies with all requirements of the American Welding Society Classification E-6011, American Bureau of Shipping, Group H1G and B1G for a.c. and other specifications qualifying it for use on war work.

Physical tests demonstrate that this electrode gives exceptionally satisfactory results. The high quality of deposited metal of the No. 230 is fully comparable to that of the best d.c. reverse polarity all-position electrodes.

Following are physical test results made on all-welded metal tensile specimens:

	As welded	Stress relieved
Ultimate tensile strength..	70,000-75,000	65,000-70,000
Per cent elongation in 2 in.	25-30	30-35

New Safety Hat

A new safety hat, made of laminated bakelite, and known as the Type P hat, has just been introduced by B. F. McDonald Co., West Coast manufacturers of safety equipment. It replaces for the duration the company's well-known Type T metal hat and incorporates the same headband suspension, making the hat quickly and easily adjustable to all head sizes.

Adequate ventilation keeps the head cool in hot weather. The headband is fully suspended to provide a cushioning hammock against the shock of heavy blows. The hat may easily be cleaned or sterilized by steaming or any other preferred method. A bulletin on the new Type P hat may be obtained from the company, 1248 South Hope Street, Los Angeles, Calif.

National Supply Co. Awarded Army-Navy "E"

The Army-Navy "E," joint Army and Navy production award, was presented to the Ambridge plant of National Supply Co. on Friday, October 2, at Ambridge High School Stadium, before a crowd of approximately 6,000, comprised of more than 2,200 employes and their families.

Principal speaker on the program was Brig. Gen. Hugh C. Minton, district chief of the Pittsburgh Ordnance district. He presented the "E" pennant to A. E. Walker, National Supply's president. Lt. Comdr. C. E. Egeler, officer in charge of naval inspection for the Munhall (Pittsburgh) area, awarded the first Army-Navy "E" pin to oldest employe A. D. Adams.

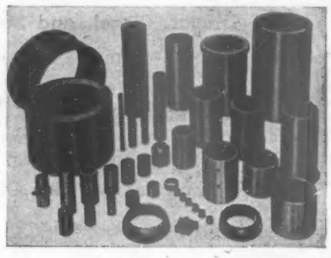
Plastic Ball and Seat Valve by Baldwin

A new plastic development has just been announced by H. W. Baldwin of Baldwin Laboratories, Saegertown, Pa. The Fleming plastic ball and seat valve for use in oil-well pumps, made of thermo plastic material, is now available after more than 2 years' experimentation and testing in actual use. Actual tests made in the Titusville and Bradford oil-producing areas show 100 per cent efficiency, 24 hours a day for at least 10 months.

Molded Fabric Bearings Replace Critical Metals

Shortage of critical bearing metals is being overcome and performance results greatly improved through the use of oil-lubricated nonmetallic molded bearings, developed by Gatke Corp., 228 North La Salle Street, Chicago.

Known as Lubritex bearings, these bearings are distinctly different from Gatke Hydrotex (water-lubricated) and Gatke Grafitex (self-lubricated) bearings in



that they are made of various material combinations developed especially to meet all kinds of service conditions using grease or oil lubrication.

According to the manufacturer, Luritex bearings are replacing conventional bearings with highly satisfactory results on all kinds of service. They stand up under impact loads that are too great for metal bearings—have much greater wear life and lower friction. Lubrication is much less critical—they do not score journals, even if lubrication fails for limited periods.

These bearings are engineered for the application and molded to finished dimensions in all shapes and sizes for replacing metal bearings. Performance results on a wide range of service conditions are described in a recent catalog.

Sonken-Galamba Purchases Refinery in Michigan

The Sonken-Galamba Supply Co. of Tulsa has purchased the Titan Oil Co.'s Dubbs refinery at Stark, Mich.

Included in the equipment which has been purchased is a 4,000-bbl. topping plant, a 2,000-bbl. visbreaker plant, and a 500-bbl. asphalt plant.

Other equipment included in the plant, which is located in Stark, a suburb of Detroit, are a complete instrument board, an electric-eye control, pump house complete with explosionproof motor-driven centrifugal pumps, 18 heat exchangers, over 50 tanks from 250 to 25,000-bbl. capacity, carload Ethyl plant, and other items of the newest type.

Sonken-Galamba maintains headquarters in Tulsa and branch offices in Kansas City to buy and sell refineries and equipment on a nation-wide scale.

ANCHOR ADDS FLEET OF NEW RAILWAY TANK CARS

In expanding its operations in the butane and propane fields, Anchor Petroleum Co., of Tulsa, announces the addition of a fleet of new railway tank cars. Delivery began in September on these new cars, and they are being put into immediate service. The tank cars are 225-lb. working pressure and are designed to handle propane, iso, or normal butane and isopentane. They were built by American Car & Foundry Co. The war has created an increased demand for Anchor-gas, according to information secured from Anchor offices, and the company has been forced to add to their transport facilities. Anchor will continue to give customers the best possible service, even though war industries have placed a big load on their transportation facilities.

In addition to tank-car service, Anchor is using motor transports for delivery in several midwestern states.

TRADE LITERATURE

WALKER-RAINS CO., 518 Eighteenth Street, Denver, Colo.—Folder on Triple-Duty Supreme Packings. The folder presents cost comparisons which illustrate savings of time and money accomplished by using these packings made in actual tests over a period of 6 years. A price list is included.

LEEDS & NORTHRUP CO., 4934 Stenton Avenue, Philadelphia, Pa.—Catalog N-33A, on Micromax Thermocouple Pyrometers. Contains 56 well-illustrated pages of information about available instruments—indicators, recorders and controllers—and about the thermocouples and accessories which are used with them.

AMONG EQUIPMENT MEN...

Fluid Packed Pump Co. Makes Mid-Continent Appointments

Fluid Packed Pump Co. announces the appointment of Sidney Shuman as general sales manager for the entire Mid-Continent division, and John Ruff as assistant manager.

Mr. Shuman joined the company in 1936 after having spent many years in the services of Sinclair Prairie

SIDNEY SHUMAN

JOHN RUFF

Oil Co. "Sid" has been a familiar figure in representing the Fluid Packed Pump Co. in the fields adjacent to Seminole, Shreveport, Smackover, Kilgore, Oklahoma City and Tulsa. He will continue to headquarter in the divisional sales office in the Hunt Building, Tulsa.

John Ruff has been with the company for the past 3 years, devoting his time to the Texas fields. For 15 years prior to that he represented Jarecki Supply Co. in southern Kansas, northern Oklahoma, and Kilgore, Tex. He will take up his duties and headquarter at the southern division sales office, 6006 Navigation Boulevard, Houston, Tex.

Ora Frame, who formerly headed the company's southern division, is now in the service with the U. S. Marine Corp.

Emsco Announces Appointment Of William T. Powell

Emsco Derrick & Equipment Co. has announced the appointment of William T. Powell as a vice president of that company effective October 1. Mr. Powell is a mechanical engineer; was graduated from the South Wales and Monmouthshire School of Mines in 1923, holds a mechanical engineering certificate of City and Guilds of London Institute, and is a member of the American Society of Mechanical Engineers. He became a citizen of the United States in 1935 and entered the Emsco organization on August 1, 1937, in the fabricated-plate division. He has been a manager of the war-materials division since that division was organized in June 1941. Mr. Powell is well known in procurement circles of the Army, Navy, aircraft and other major war-material manufacturers.

Oil Well Supply Co. Transfers Keim to Oil City, Pa.

Oil Well Supply Co. announces the transfer of L. H. Keim, vice president in charge of its West Coast operations, to the company's manufacturing headquarters at Oil City, Pa.

The increased war-production activities in Oilwell's plants require the addition of executive personnel for the duration, and Mr. Keim's background and experience in manufacturing and field service will be particularly valuable to the company's plant operations in the present war effort.

Mr. Keim is a native of Pittsburgh, Pa., where he received his technical and practical training. Following the first World War, he was appointed general sales manager of the Nuttall division.

Nuttall and Oilwell collaborated in the design and development of special drilling equipment, after which Mr. Keim joined the Oilwell organization and was transferred to California. He was appointed general manager in charge of sales and manufacturing operations, and since 1929 has served as vice president.

Clifford Named Vice President Of National Supply Co.

George E. Clifford was elected a vice president of National Supply Co., Pittsburgh, Pa., effective as of October 19, 1942. Mr. Clifford will supervise the sales of certain munitions, in addition to his present responsibilities as vice president in charge of sales for Spang Chalfant, Inc.

Herrington Elected Director Of Aviation Corp.

Another war-production executive has allied himself with the aviation industry to help the United Nations fill the skies with wings to defeat the Axis. Tom Girdler's place on the directorate of the Aviation Corp. has been taken by A. W. Herrington, board chairman of Marmon-Herrington, while Mr. Girdler will devote his time chiefly to the operation of Consolidated and Vulgate Aircraft, both of which are Aviation Corp. affiliates. Mr. Girdler will still be available to the parent corporation for consultation.

Emsco Advances Blake Caldwell

Blake Caldwell has been advanced from the position of chief engineer of the D+B division to the position of manager, in charge of all operations of the D+B Mid-Continent division of Emsco Derrick & Equipment Co. Mr. Caldwell is a graduate of the A. & M. College of Texas, receiving the degrees of bachelor of science in engineering and master of science. He also served for 3 years as a member of the A. & M. faculty. His early training was acquired as assistant engineer for Gulf Refining Co., and as engineer for Tulsa Boiler & Machinery Co. Prior to his first connection with Emsco he was chief engineer of Walter O'Bannon Co., Tulsa.

For the past 10 years he has been actively engaged in A.P.I. standardization work. At the present time in addition to his regular duties, Mr. Caldwell is chairman of the subcommittee of rating hoisting tools, secretary of the manufacturers' subcommittee on pumps, and a member of the manufacturers' subcommittee on sucker rods. He is a member of the American Petroleum Institute.

Thompson Visits Tulsa

L. A. Thompson, Mid-Continent representative for Vortox Manufacturing Co., Claremont, Calif., was in Tulsa recently on a business trip. Mr. Thompson's headquarters are in Dallas, Tex.

Distributor for B and W Guides

B and W, Inc., announces the appointment of the W. L. Somner Co., 419 Lake St., Shreveport, La., as their distributor for B and W wall-cleaning guides in the northern Louisiana and Arkansas territory. Complete stocks will be maintained and field installation service provided.

SEISMOGRAPH SERVICE CORP. HOLDS WARTIME MEETING

The second annual supervisors' and party chiefs' technical meeting was the feature of Seismograph's eleventh anniversary program, held in Tulsa, November 7 and 8.

A total of 46 men from the executive staff, the research department, field superintendents and party chiefs attended the meetings. Several party chiefs from the foreign division were in attendance, including R. B. Aldredge, recently manager of the foreign division.

A number of customers and friends from local oil companies attended the Saturday afternoon meeting, when addresses were made by G. W. Westby, Dr. J. E. Hawkins, H. M. Thralls, E. J. P. van der Linden, A. C. Austin, C. W. Blakey and W. E. Pugh.

At the Saturday luncheon held in the Mayo Hotel, G. H. Westby, president, presented 5-year service pins to party chiefs—J. A. Reis, W. B. Perry, H. R. Breck, G. A. Grimm and George Brothers.

Front row, left to right: G. M. Giltinan, secretary; T. A. Manhart, first vice president; G. H. Westby, president; A. J. Barthelmes, second vice president; A. B. Chappell, treasurer. Remainder, seated, left to right: L. G. Cornish, geologist; R. W. Mossman, party chief; H. R. Breck, party chief; G. A. Grimm, party chief; H. M. Thralls, supervisor; A. A. Fitch, party chief; J. L. Kezeler, instrument supervisor; J. G. Jackson, party chief; B. F. Rummerfield, party chief; A. C. Austin, supervisor; N. K. Moody, party chief; C. C. Brooks, supervisor; F. B. Leedy, supervisor; W. B. Perry, party chief; R. F. Aldrege, tropical division; W. R. Meeks, surveyor supervisor; S. W. Wilcox, public relations; E. J. P. van der Linden, geophysicist; J. E. Hawkins, research physicist; D. F. Smith, party chief; G. W. Reed, operations supervisor; R. E. McMillen, party chief; W. E. Pugh, supervisor; H. H. Andrews, supervisor; M. L. Burr, surveyor supervisor; C. W. Blakey, party chief. Standing, left to right: J. E. Dorris, party chief; R. J. Graf, party chief; J. A. Ries, party chief; R. G. Hill, assistant party chief; W. B. Sibley, research assistant; W. A. Rutledge, computer; F. A. Karns, operations assistant; H. C. Becker, party chief; R. C. Hannum, computer; T. S. Green, party chief; T. A. Gilmartin, research assistant; J. L. Gartner, geologist; Van Roberts, surveyor supervisor; C. E. McClure, party chief; J. L. Hollis, party chief

CLASSIFIED ADVERTISING

THE MARKET PLACE OF THE OIL INDUSTRY . . .

Patent Attorneys

PATENTS — TRADE MARKS

All cases submitted given personal attention.

Form "Evidence of Conception" with instructions for use and "Schedule of Government and Attorney's Fees"—FREE.

LANCASTER, ALLWINE & ROMMEL
Patent Law Offices
618 Bowen Bldg., Washington, D. C.

Leases and Drilling Blocks

LEASES—East Texas, La., South Ark. 20 acres up, dollar acre up.—Owners—Address Attorney, Box 1122, Little, Rock, Ark.

LEASES ROYALTIES

PRODUCING OR NONPRODUCING

Texas, New Mexico, Oklahoma.
Louisiana and Illinois
20 Years' Experience
Inquiries Invited

B. D. BUCKLEY

60 Broadview Drive, Clayton
St. Louis, Mo.

FOR SALE: Oil and Gas Leases on proven structures, drilling propositions, small production and fluorspar deposits. Reports furnished. W. P. Harley, Bowling Green, Kentucky.

GEORGIA
Deep Drilling now on in Georgia. For information write, C. W. DEMING, Waycross, Ga.

ILLINOIS WILDCATTER
Thoroughly posted as to possibilities for shallow production, in Coles and Edgar counties, acreage for sale, or for test. Sam J. Burkitt, Chrisman, Ill.

FOR INVESTMENT with great opportunity from oil, buy land developing R.M. area, $7. acre. Box B-321, The Oil and Gas Journal, Tulsa, Okla.

FOR SALE: Oil and gas leases North and South Dakota, ten cents acre. Owner, P. O. Box 1163, Tulsa, Oklahoma.

8000 ACRE STRUCTURE full geology, geophysical, cored, equipped rotary & cable. Contractor drafted. Must deal for completion. S. W. Pressey, Pueblo, Colo.

PARTIES to join me 400 acres leases and royalty, Picher, Oklahoma mining field, 4 shafts ready be equipped for zinc production. O. D. Baker, Miami, Okla.

Royalties

ANDREW J. BARRETT
The Philtower
Tulsa, Oklahoma.

WE BUY & SELL all types of Oil and Gas Royalties. Sales restricted to registered dealers only. Grimes Royalty Co., National Mutual Bldg., Tulsa, Okla.

FOR SALE: Landowner's Royalty under 160 acres leased to Humble Oil & Ref. Co. in Lea Co., N. M. North of the Big Hobbs Pool. 27 pools in County, HARRY S. WRIGHT, FARMINGTON, N. M.

Financing

CAPITAL SEEKERS — Interested in raising $25,000 or more for a legitimate project should communicate with AMSTER LEONARD, Fox Theater Bldg., Detroit, Mich.

CORPORATION FINANCING, mining or oil. Services and facilities offered to assist undertaking merit. Box B-300, The Oil and Gas Journal, Tulsa, Okla.

Incorporation

DELAWARE CHARTERS: Complete service $35. Submitted forms. Chas. G. Guyer, Inc., Wilmington, Delaware.

Oil Industry Printing

OIL FIELD LEGAL BLANKS
Leases, assignments, releases, township plat books, well records, etc. Request on your letterhead gets free catalog. Olds Press 215 East Third St., Tulsa, Okla.

Legal Blanks

THE BURKHART LINE of Legal Blanks Since 1908. Oil-Gas and Business Forms for Mid-Cont. and Illinois Basin. Leases Rev. with Gov.'s Regulations. Catalog and Samples. Burkhart Ptg. & Sta. Co., 115 So. Cincinnati, Tulsa, Okla.

Help Wanted

NOTICE TO ADVERTISERS

Advertisers offering positions to workers skilled in critical war industries are requested by the War Manpower Commission to include the following sentence in their advertisement:

"Applications from those now employed in war industries will not be considered."

ENGINEERS WANTED
Chemical or Mechanical with minimum one year oil refinery plant operation or maintenance experience. Require University Engineering School graduate with basic knowledge principles fluid flow. To work on process flow sheets, equipment selection and general handling oil refinery. Defense Contracts as assistant to senior engineers. No aliens or men engaged Defense work considered. Opportunity up to individual. In reply state experience, education, draft status, salary expected. Foster Wheeler Corporation, Room 2402, 165 Broadway, New York.

OIL WELL service company needs engineers for field work. Must be over 45 years old or draft-exempt. Must be willing to do shift work and be free to move. Salary $200 per month and up, depending upon experience. In reply, state experiences, draft status, and accompany with recent photograph. Box B-352, The Oil and Gas Journal, Tulsa, Okla.

Situations Wanted

LABORATORY foreman, 45 years old, draft classification 3B, well versed in treating and mercaptan removal, C. F. R. knock engine operation and maintenance. Experience covers asphalt, lube oils and light oils. Box B-350, The Oil and Gas Journal, Tulsa, Okla.

If we do not maintain a classification exactly suited to the type of advertisement you wish to run we shall be glad to create a fitting one. *Classified Department.*

Equipment Wanted

WANTED

Abandoned *Pipe Lines*, in or out of the ground, *Oil Wells, Steel Buildings* and Steel Storage *Tanks* of all sizes.

JOS. GREENSPON'S SON PIPE CORP.
National Stock Yards, St. Clair Co., Illinois.

WANTED — Steel tanks total 120,000 gallon capacity. Will take 5000 gallon or larger. Tidewater Equipment & Machinery Corp., 305 Madison Ave., New York, N. Y.

ONE—3000 to 5000 KW Generator, 3 phase, 60 cycle, 6600 Volt, 3600 RPM, AC.
INDUSTRIAL EQUIPMENT CO.
338 Baronne St., New Orleans, La., RA. 0889

1 SET of Hydraulic Casing Pulling Jacks for 2,000' wells, must be reasonable. A. A. Gilbert Pipe & Supply Co., P.O. Box 986, Shreveport, La.

WANTED TO BUY

Pipe of all sizes, 2" to 16", inclusive, also refineries, pipe lines and abandoned wells. Wire, write or phone

Louisiana Iron & Supply Co.
Shreveport, La.

DIESEL ENGINES
Total 1600 HP required, with or without Generators. Consider units 225 HP and larger. Also smaller high speed units for standby service. Preference given units immediately available. Give complete details and price. Address Purchasing Department, Box B-353, The Oil and Gas

WANT TO BUY

127 miles (or any substantial part thereof) of 10" minimum seamless steel pipe suitable for gas line. Write Box B-351, The Oil and Gas Journal, 415 Lexington, New York, N. Y.

For Sale—Equipment

FOR SALE: 4—5¾ & 6¾ x 12 Airline Slush Pumps; good condition; very reasonable. W. J. Perlitz, 2720 Bernhardt Drive, Phone 6978, Port Arthur, Texas.

For Sale—Equipment

TANKS FOR SALE
220,000 gal. 43' x 20' Steel Tank. 1—14,000 gal. and 2—11,000 gal. and 1—8,000 gal. Steel Tanks. 12—9' x 8' Wood Tanks 2—10,500 bbl. 50' x 30' steel tanks with steel roofs.
L. M. STANHOPE
Wayne, Penna.

TRUCKS

2—International Model KS-7, 176" wheelbase chassis, 6.14 & 8.52:1 gear ratio; 8.25 x 20 10-ply front and 9.00 x 20 dual rear tires; standard cab, two-speed rear axle; equipped with Tulsa Winch Manufacturing Company split shaft power take-off.

1—International Model K-8-F tandem, 197" wheelbase chassis, 7.16:1 gear ratio; 8.25x20 10-ply front and 9.00 x20 dual rear Ground Grip tires; standard cab, FBC-401 engine with F-52-C transmission; equipped with Tulsa Winch Mfg. Company split shaft power take-off and Model 18 winch mounted on rear of truck under chassis.

The Parkersburg Rig & Reel Company
O. C. S. Division
Coffeyville, Kansas
Phone LD 7022 P. O. Box 573

FOR SALE: 15,000' Used ¾" Pull Rods with turtle back connections in perfect condition, 10c per ft. A. A. Gilbert Pipe & Supply Co., Box 986, Shreveport, La.

10,000 ft. 2½" Standard black pipe. New threads. Good condition. J. S. McLaughlin & Sons, 4047 Urbandale Avenue, Des Moines, Iowa.

2—120 HP, 650 RPM, rebuilt Diesel engines, power units.
1—200 HP, 514 RPM, completely rebuilt Diesel engine, power unit.
The two above can be supplied with Generators if desired.
2—66 HP Boilers.
1—75 HP variable speed A.C. motor.
Also variable sizes small alternating current motors.
K. S. RICHARDS
P.O. Box 443, Fort Worth, Texas
Phone 3-5600

FOR SALE — Type 5-C-3 Union Tool Unitized Draw Works with Automatic Cathead. A-1 Shape. Make Offer. P. O. Box No. 1513, Oklahoma City, Okla.

1 COOPER-Bessemer 8 cylinder engine. Type G M R size 12" x 14", 225 HP direct connected to Cooper-Bessemer Compressor, high side 12" x 14", low side 6½" x 14". Exqellent condition. Box B-291, The Oil and Gas Journal, Tulsa Okla.

TWO vertical type Askania Magnetometers. Also one complete Heiland resistivity outfit. Write Box B-285, The Oil and Gas Journal, Tulsa, Okla.

FOR SALE: Two Kobe Triplex pumps with Buda engines 3 down hole production units, and all assembly complete to pump 3 wells. Excellent condition, less than 2 years old. Priced right. Box 653, Blackstone Hotel, Tyler, Tex.

FOR SALE: 7¼ x 14 Oil Well Power Slush Pump. Melton Machinery & Supply Co., Seminole, Okla.

FOR SALE at Oklahoma City: Ten 70-HP, 175# WP, F & T, LFB used reconditioned boilers. Cities Service Oil, Patridge, Bartlesville, Okla.

1 BESSEMER Compressor 80 B.H.P. 16x20" Power Cylinder 11½x20" Compressor Cylinder. Mercoid Controls. Harvard Gas Company, 502 K.B.&T. Bldg., Charleston, West Va.

⅞" Oklahoma City used sucker rods, 50,000 feet, good condition. 50—30 and 12" x 23' Channels. 2—24" x 20' Beams and some short pieces, smaller sizes Some reinforcing sucker rods, all at Oklahoma City. M. R. Travis, 1702 S Boulder, Tulsa, Okla.

CLASSIFIED ADVERTISING RATES

Classified advertising rates: First insertion, 35 cents a line; each additional insertion, 25 cents a line, PAYABLE IN ADVANCE. Six words usually make a line. Count as a word each one-letter word and each group of figures. White-space computed at regular line rate. Allow two extra lines for blind ads. Ads of less than three lines not accepted. No formal acknowledgment is made, and proofs cannot be shown in advance of publication.

	1 time	2 times	3 times	4 times		1 time	2 times	3 times	4 times
3 Lines	$1.05	$1.80	$2.55	$3.30	7 Lines	$2.45	$4.20	$5.95	$7.70
4 Lines	1.40	2.40	3.40	4.40	8 Lines	2.80	4.80	6.80	8.80
5 Lines	1.75	3.00	4.25	5.50	9 Lines	3.15	5.40	7.65	9.90
6 Lines	2.10	3.60	5.10	6.60	10 Lines	3.50	6.00	8.50	11.00

CLASSIFIED DISPLAY RATES

Classified Display is set with a border and may be used in one or two column sizes.

1 Inch	1 time	$5.00
1 Inch	13 times	4.50 per inch
1 Inch	26 times	4.00 per inch
1 Inch	52 times	3.50 per inch

This space may be contracted for over a period of one year from the date of the first insertion and is PAYABLE IN ADVANCE, MONTHLY.

We reserve the right to withhold all advertising of questionable character. To avoid delay be sure to send remittance with copy. We will set your ad in the smallest amount of space possible and refund all overpayments. One-time insertions will not be run until fully paid. Forms close MONDAY NOON before each issue date.

THE OIL AND GAS JOURNAL
Tulsa, Oklahoma

COMPLETE DUBBS REFINERY FOR SALE

Vis-Breaker, Topping and Asphalt Plant

4,000 barrel topping—2,000 barrel Vis-Breaker—500 barrel Asphalt—Less than 25,000 barrels of crude ever put through this plant. Complete instrument board, new, never hooked up. Electric-eye control. Pump house complete with explosion proof motor driven centrifugal pumps.

18 heat exchangers. Over 50 tanks from 250 barrels to 25,000 barrels included. Car load Ethyl plant. Latest type of equipment offered for sale by any refinery.

Location: Titan Oil Co., Stark, Mich. (Detroit suburb) For sale in its entirety, parts or will lease in its entirety. Have complete Universal Oil Company's inspection report, together with all blue prints.

SONKEN-GALAMBA SUPPLY COMPANY

W. C. Berry or H. J. Galamba
Riverside at Second, Kansas City, Kansas

Robert W. Duden
Union Ave. at Twenty-First, Tulsa, Oklahoma

FOR SALE

1—Crude heater complete with accessories, capacity 2000 bbl. Built new 1939 by Foster Wheeler Corp.

1—Perco copper sweetening unit complete, including steel building. Capacity 500 bbl. Located Great Bend, Kansas.

SONKEN-GALAMBA SUPPLY CO.
Union Ave. at Twenty-First St.
Tulsa, Okla.

FOR SALE

Model H. Fort Worth spudder with few tools and McCormick-Deering tractor. Quick sale, $600.00 cash.

One A mast pole suitable for cable tools or light rotary, 75 ft. high with five sheave header made of 10 in. pipe—Breaks in the middle—$350.00.

One Fordson tractor with winch—$125.00.

One model D Fort Worth spudder—$700.00.

One 20 H.P. Superior engine with good clutch—$150.00.

S. H. WALTON
3304 Main St., Wichita Falls, Texas.

FOR SALE: 27½" Ideal Rotary Table, 5 sheave 200 ton Crown Block, 4 sheave 72" traveling block, 8" Ideal enclosed rotary hook. Melton Machinery & Supply Co., Seminole, Okla.

FOR SALE AT BARGAIN—2 complete drilling rigs, 1 Unit Rig Company U-10 with 18,000 Diesel caterpillar with 7½ x 12 G. D. pump; also 1 type R. Cardwell double drum draw works, 160 HP engines ready to move on job. Box 1489 Tulsa, Okla.

FOR SALE: 12 K.W. Portable Light Plant Powered by 35 H.P. International Engine. Melton Supply Co., Seminole Okla.

---

25 K.W. and 40 K.W. Gas Engines, 220 volts, D.C. Two 100 K.W. Gas Engine-Generator Sets, 220 volts, D.C. 7x6 Ingersoll-Rand ER-1 Air Compressor. Six-inch Oster Pipe Threading Machine. Also large stock of lathes, pipe machines, milling machines, etc. Send for our list.
Terms to suit.

CINCINNATI MACHINERY & SUPPLY CO.
26 West 2nd St., Cincinnati, Ohio.

FOR SALE: Approximately 250—2", 3", 4" and 6" LH EH SL UP Klein Pipe Tongs, used. $1.00 per inch per tong. Patridge, Cities Service Oil, Bartlesville.

DIESEL—GAS—ENGINES

Large selection — All sizes and types. Generator units, marine engines, gasoline engines, auxiliaries—boilers, steam engines, and turbo-generator sets.

Complete information on request.

A. G. SCHOONMAKER COMPANY
48 Church Street, New York, N. Y.

FOR SALE: Star Mfg. Company, portable cooling tower, telescoping type, 7' wide, 13' long, 8' high. All steel. Melton Machinery & Supply Co., Seminole, Okla.

FOR SALE—COMPLETE KELLOGG PLANT

4,000 barrel Kellogg 2-coil Cracking and Vis-Breaking Unit equipped with 1,000 barrel asphalt vacuum tower.
4—Turbine driven hot oil pumps.
3—Simplex steel cylinder pumps.
1—two-stage steam driven duplex charge pump.
2—brand new Kellogg heat exchangers, never been used.
Complete set of control instruments.
Original cost over $750,000.00. Will sell in its entirety, $195,000.00. This unit has been reserved to be re-erected at another location. Blueprints and complete data available.

ALLIED OIL TERMINAL COMPANY
Phone 5-0324 1601 Columbia Mutual Tower Bldg.
MEMPHIS, TENNESSEE

FOR SALE: 1—29-W Bucyrus-Erie All Steel Drill, equipped with six cylinder Buda motor, 45' mast, Twin-Disc clutches. Machine and motor completely overhauled, in A-1 condition. Priced reasonable. B. M. McGraw, Box 190, Carmi, Ill.

FOR SALE: 30—1½ KW Steam Turbine Generators. $25.00 each. Patridge, Cities Service Oil, Bartlesville, Okla.

BUY AND SELL

Used Engines, Compressors, Power Plants and Gasoline Plant Equipment.

We Rebuild and Guarantee

L. F. SMITH CO.
217 W. Archer, Tulsa, Okla.

FOR SALE

178, 55-ton DOUBLE HOPPER CARS, USRA TYPE

All-steel, self-clearing: 1880 feet capacity. Built 1920, 1921 and 1922

A-B Brakes and full "U" Truck Frames

Also, fair quantity of New Repair Materials available.

MUST BE DISPOSED OF IMMEDIATELY, so if of interest ACT NOW!

IRON & STEEL PRODUCTS, INC.
37 years' experience
13412 S. Brainard Ave. Chicago, Illinois
"ANYTHING containing IRON or STEEL"

USED SPUDDER

Almost New (used less than 9 months) "Cardwell" Model K Double Drum Spudder with Mast, Steel Top, Side Curtains, Drilling Tools, Hand Tools, Fittings, 145 H.P. Waukesha Engine, 1500 Watt Kohler Light Plant and Wire Lines; 5,000 Foot Drilling Capacity.

Everything in fine condition. Best Used Spudder value in the oil country. Ready for immediate delivery from our yards at Salem, Illinois.

THE BRIDGEPORT MACHINE COMPANY
WICHITA, KANSAS

2—450 H.P. Water Tube Boilers, 1—655 H.P. Water Tube Boiler.
2—Steel Buildings 80'x135' and 70'x104'.
2—3000 c.f.m. Air Compressors.
1—2500 c.f.m. Air Compressor.
Large Assortment of Small Compressors.
1—100,000 gal. Steel Tank on 100 Foot Tower.
1—25,000 gal. Steel Tank on 60 Foot Tower.
1—35,000 gal. Steel Tank on 50 Foot Tower.
1—Bucyrus 3½ Yard Diesel Dragline.
1—Bucyrus 18 Ton Steam Crane on Cats.
2—5,000 Barrel Steel Storage Tank with Wooden Roofs. Large assortment of smaller tanks.
Large assortment of used Steel Plates, I-Beams, Channels, Pipe and Fittings.

INDUSTRIAL EQUIPMENT CO.
338 Baronne St., New Orleans, La.
RAymond 0889

USED STEEL STORAGE TANKS
VERY GOOD CONDITION
READY FOR IMMEDIATE SHIPMENT
Riveted—Match-Marked—Knocked-Down
1—20,000 bbl. 75' dia. x 25'5"
1—30,000 bbl. 90' dia. x 25'6"

5—10,000 gal. 7' dia. x 35'
3—20,000 gal. 12' dia. x 24'
3—Rectangular 14' x 10' x 7'
10—Truck tanks, 600 to 1800 gal. 1 to 6 compartments.

J. C. MARTYNS
Gen. P.O. Box 297, New York City

FOR SALE: Complete Wilson Portable Rotary Rig with telescoping mast, suitable for 2,000 ft. drilling. Melton Machinery & Supply Co., Seminole, Okla.

Increase Shown in Converting Domestic Oil Heating Plants

WASHINGTON, D. C.—Although the record still is far from satisfactory, conversions of domestic heating plants in the East Coast area from oil to coal have been at a slightly accelerated pace the last 6 weeks, according to Petroleum Coordinator Harold L. Ickes. Householders now are beginning to realize the seriousness of the oil situation on the East Coast, he said.

So far only 4 per cent, or approximately 57,000 householders have converted, according to a detailed East Coast fuel-oil survey. This will result in a saving of only about 2,850,000 bbl. of light fuel oil yearly, it was pointed out. It is estimated that 50 per cent, or 712,000 East Coast domestic consumers can convert without undue complications. This would save approximately 35,625,000 bbl. of light fuel oil yearly. More than 27,000 domestic fuel-oil consumers in the area are in process of converting, and 2,850 others have committed themselves to convert in the near future.

ADVERTISERS IN THIS ISSUE

Abercrombie Pump Co. 262
Acme Fishing Tool Co. 176
Air Reduction Sales Co. 1
Ajax Iron Works 110
Alco Products Div. of American Locomotive Co. 12
Alcorn Combustion Co. 128
American Flange & Mfg. Co., Inc. 49
American Meter Company 183
American Roller Bearing Co. 213
American Steel & Wire Company 92-93
Anchor Petroleum Co. 142
Anderson Co., James 246
Armstrong Machine Works 42-268
Atlas Supply Co. 167
Baash-Ross Tool Company 131
Babcock & Wilcox Tube Company, The 205
Baldwin-Duckworth Division of Chain Belt Company 44
Bantam Bearings Corp. 173
Baroid Sales Division, National Lead Company 31
Barret, William M., Inc. 261
Bechtel Co., W. A. 119
Bechtel-McCone-Parsons Corp. 155
Brewster Company, Inc., The 268
Briggs & Stratton Corp. 122
Brown & Brown, Inc. 268
Brown Instrument Co., The 161
Buchanan, Al 261
Buckeye Traction Ditcher Co. 33-248
Bucyrus-Erie 39
Burke-Greis Oil Co. 208
Cable, Jo H. 253
Cameron Iron Works, Inc. 37
Cardwell Mfg. Co., Inc. 2
Carey Company, The Philip 6
Cast Iron Pipe Research Association, The 70
Century Electric Company 21
Chaplin-Fulton Mfg. Co., Inc. 260
Chapman Valve Mfg. Co., The 30
Chemical Process Co., Inc., The 148
Chicago Bridge & Iron Company 170-171
Clark Brothers Company 116-117
Classified Advertising 276-277
Cleveland Trencher Company 254
Coffing Hoist Co. 186
Columbia Steel Company 92-93
Columbian Steel Tank Co. 13
Continental Supply Company, The 159
Cooper-Bessemer Corp., The 68
Crane Co. 7
Curtin, W. H., Co., The 262
Davis Regulator Co., The 178
Dearborn Chemical Co. 123-246
Deep Rock Oil Corp. 245
Dresser Mfg. Co., The 208
Dugas Engineering Corp. 172
Dura metallic Corp. 165
Eastman Oil Well Survey Co. 211
Edward Valve & Mfg. Co. 193
Elastic Stop Nut Corp. 194
Elliott Company 244
Ethyl Gasoline Corporation 18
Filtrol Corporation 197-198
First National Bank & Trust Co. of Tulsa, The 252
Flori Pipe Co., The 15
Fluid Packed Pump Co. 177
Fluor Corporation, Ltd., The 85
Foster Wheeler Corp. 144-145
Four Wheel Drive Auto Co., The 38
Foxboro Mfg. Co., The 34-35
France Mfg. Co. 114
Franks Mfg. Co. 218
Frick-Reid Supply Corporation 189
Gardner-Denver Company 10
Gaso Pump & Burner Mfg. Co. 95
General American Transportation Corporation—Terminal Division 100
General American Transportation Corporation—Plate & Welding Division 253
Globe Steel Tubes Company 130
Goodrich Company, The B. F. 3
Gott, H. P., Mfg. Co. 258
Graver Tank & Mfg. Co., Inc. 240
Guibersen Corporation 185
Gulf Oil Corp. 17
Haering & Co., Inc., D. W. 258
Hanlon-Buchanan, Inc. 52
Harnischfeger Corporation 192
Hazard Wire Rope Division of American Chain & Cable Co., Inc. ..... Inside Back Cover
Helmerich & Payne, Inc. 245
Hewitt Rubber Corp. 19
Hill Co., J. I. 114
Houdry Process 267
Hughes Tool Co. ..... Back Cover
Humble Oil & Refining Co. 207
Hydril Co. ..... Front Cover
Independent Exploration Company 248
Industrial Engineering Co. 127
Ingersoll-Rand 134-135
International Harvester Co. 83
International Nickel Company, Inc., The 50
Jarecki Manufacturing Company 149
Jenkins Petroleum Process Co. 201
Jergusen Gage & Valve Co. 187
Johns-Manville Corporation 194
Jones Co., S. M. 221
Jones & Laughlin Steel Corporation 20
Kellogg, M. W., Company, The 47-103
Kellogg Switchboard & Supply Co. 201
Kennedy Valve Mfg. Co., The 162
Kent, George, Ltd. 212
Keuffel & Esser Co. 190
Key Co. 157
Landis Machine Company, Inc. 11
Laughlin Co., The Thomas 158
Leeds & Northrup Co. 105
Le Roi Company 99
Leschen, A., Sons, Rope Co. 143
Lincoln Electric Company, The 72
Link-Belt Company 5-109
Lone Star Cement Corporation 146
Lucey Boiler & Mfg. Co. 121
Lufkin Rule Co. 104
Lummus Co., The 137-138
Lunkenheimer Co., The 27
McCord Radiator & Mfg. Co. 288
McKee & Co., Arthur G. 141
Manhattan Rubber Mfg. Division 174
Marley Company, The 4
Marmon-Herrington Co., Inc. 22
Marsh, James P., Corp. 158
Martin & Co., Chas. 246
Mathey Mach. Works, C. A. 212
Merco Nordstrom Valve Co. 163-164
Metric Metal Works 183
Mid-Continent Petroleum Corp. 132
Midwest Piping & Supply Company, Inc., The 25
Mission Mfg. Co., The 175
Monsanto Chemical Company 30
Morse Chain Company 160
Murray Iron Works Co. 243
National Bank of Tulsa 222
National Carbon Co., Inc. 169
National Supply Co., The 112-113
Naylor Pipe Company 152
New Bedford Cordage Co. 258
Oil Center Tool Co. 214
Page Fence Association, Div. of American Chain & Cable Co. 206
Patterson-Ballagh Corporation 195
Penberthy Injector Co. 65
Penn Electric Switch Co. 124
Petro-Chem Development Co., Inc. 125
Petroleum Electric Power Association 191
Petroleum Rectifying Company 14
Phelps Dodge Refining Corp. 243
Pittsburgh-Des Moines Steel Company 190
Pittsburgh Equitable Meter Co. ..... Inside Front Cover
Plymouth Cordage Co. 91
Powell, Wm., Co., The 24
Preformed Wire Rope Div. of American Chain & Cable Co. 28
Price, H. C. Co. 97
Pure Oil Co. 49
R-S Products Corp. 133
Reeter Well Equipment Co., Inc. 216
Reed Roller Bit Company 202
Republic Steel Corporation 16
Roeblings Sons Company, John A. 115
Schlumberger Well Surveying Corporation 107
Shell Oil Company, Incorporated 28
Skelly Oil Co. 120
Smith, A. O., Corporation 98
Southern Mill & Mfg. Co. 178
Southwestern Gas & Elec. Co. 166
Spang & Company 196
Sperry-Sun Well Surveying Co. 160
Spicer Mfg. Co. 238
Standard Oil Co. (Indiana) 245
Staynew Filter Corp. 151
Sterling Machinery Corp. 206
Stratford Engineering Corp. 41
Taylor Forge & Pipe Works 46
Taylor Instrument Companies 88
Texaco Development Corporation 40
Thompson Products, Inc. 206
Thornhill-Craver Co. 253
Timken Roller Bearing Company 32
Timken Roller Bearing Company, Steel & Tube Division 29
Tretolite Company 181
Union Wire Rope Corporation 150
United States Steel Export Company 92-93
Universal Oil Products Co. 67
Vapor Recovery Systems Co., The 129
Viking Pump Co. 130
Vogt, Henry, Machine Co. 8
Wagner Electric Corporation 45
Wall-Colmonoy Corp. 136
Warren Petroleum Corporation 101
Webster Engineering Co., The 88
Westinghouse Electric & Mfg. Co. 90
Wheatley Bros. Pump & Valve Mfrs. 247
Wheland Company, The 153
Wickwire Spencer Steel Company 43
Wilson Manufacturing Co., Inc. 9
Worthington Pump & Machinery Corporation 23
Young Engine Corp. 269
Zink, John, Co. 147

CALENDAR

November

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, thirty-fifth annual meeting, Netherlands Plaza Hotel, Cincinnati, Ohio, November 16-18.

AMERICAN ASSOCIATION OF OILWELL DRILLING CONTRACTORS, second annual meeting, Mayo Hotel, Tulsa, November 19-20.

AMERICAN CHEMICAL SOCIETY, national chemical exposition and national industrial chemical conference, Sherman Hotel, Chicago, Ill., November 24-29.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting, New York. November 30-December 4.

December

NEW MEXICO OIL AND GAS ASSOCIATION, annual meeting, Artesia Hotel, Artesia, N. M., December 2.

PETROLEUM ACCOUNTANTS SOCIETY OF OKLAHOMA. Hotel Mayo, Tulsa, December 17.

INTERSTATE OIL COMPACT COMMISSION, annual organization meeting, Biltmore Hotel, Oklahoma City, Okla., December 18-19.

1943

February

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, New York, February 15-18, 1943.